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PINYON-JUNIPER TYPE SPECIES:
ECOLOGY, BIOLOGY AND MANAGEMENT RESEARCH

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By

Harold B. Betton
Natural Resource Specialist
Division of Forestry

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THE PHYSICAL AND BIOLOGICAL FACTORS AFFECTING MAINTENANCE AND MANAGEMENT OF PINYON-JUNIPER TYPE SPECIES OF THE WEST

by

Harold Betton
Natural Resource Specialist
U. S. Department of the Interior
Bureau of Land Management
Division of Forestry
Washington, D. C.

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FOREWORD

The birth of our nation rendered our forefathers vast forest lands with abundant wildlife both plant and animal. With the opening of our frontiers, settlers moved in and began utilizing these available resources. The advent of industry and railroads brought America to higher economic brackets and increased international trade.

Since the bulk of our resources was found in the wilderness, industrial geniuses began to develop methods for the extraction of these resources. The perpetuation of this practice necessitated the federal government's establishing forest land officials or Timber Agents and later establishing the United States Forest Service. The primary purposes of these agencies were to protect the public (government owned) lands and later management of the forest reserves in western United States.

At the present time, the United States Government owns 60,000,000 or more acres of Pinyon-Juniper type forest land in the west. Management criteria have, in some cases, not been adequate to obtain certain desired goals. Forest managers often enacted certain practices without sufficient knowledge of the area. Specialists hired in the various disciplines such as agronomy and range management helped to improve results of management programs.

When any scientist seeks to develop criteria, whether it be for management, basic or applied academic research, it is imperative that a review of the literature be done.

It is recognized that the literature concerning research on Pinyon-Juniper type species is in abundance relative to other species under current management by the Forest Service and the Bureau of Land Management.

Therefore it will be the purpose of this publication to summarize the literature involving Pinyon-Juniper type species and closely related species under current management in western United States.

Harold Betton

INTRODUCTION

The Federal Government owns 60,000,000 or more areas of land inhabited by pinyon-juniper type species as well as forbs, shrubs and grasses. The current emphasis is placed on proper management techniques for this area.

The uprising need for utilization of some public lands for grazing cattle, sheep, goats and other range animals caused the invasion of pinyon (10,25,26)(*Pinus edulis* and *Pinus monophylla*) and juniper (10, 25,26)(*Juniperus osteosperme*, *J. communis* et al. species of *Juniperus*) type species into Nevada, Utah, Arizona, and Colorado (36,78,79,80,83, 85, 130). This gave the forest scientists an excellent chance to gather quite a body of data regarding the ecology of these invading species.

Several programs have been developed to adequately manage our public forest lands. A summary of the most important research in the area is found in the pages to follow.

In order to facilitate an orderly discussion of all material, the paper will be divided into four parts with each part divided into sub topics.

INTRODUCTION

The federal government pays [illegible] annually [illegible] used by private [illegible] as well as [illegible] accounts. The [illegible] placed for this study.

The [illegible] cattle, sheep, goats and [illegible] the [illegible] and [illegible] species [illegible] a body of data regarding [illegible]

Several [illegible] interest lands.—A [illegible] found in the pages to follow.

In order to facilitate [illegible] will be [illegible]

PART I

LITERATURE REVIEW

I. Taxonomy of the pinyon-juniper type species with reference to the areas where they are found

II. Ecology of the pinyon-juniper area

   A. Physical information-elevation, temperature, soil, climate

   B. Animal wildlife found in the pinyon-juniper type areas

III. Basic research involving biological information with reference to growth and maintenance of Pinyon-juniper types on public lands

IV. Management practices in the pinyon-juniper area

V. Effects of management practices on:

   A. Animal flora

   B. Plant flora

   C. Soil and other edaphic characters

   D. General physiognomy of the area

Taxonomy of Pinyon-Juniper Type Species

The pinyon-juniper types are peculiar to certain elevations resulting in specie domination in certain areas. The reasons for such occurrences could stretch from differential selection of species to various areas to more ontogenetic explanations (7, 94). Woodbury (78) has definitely characterized the plant flora at different elevations in the Utah Mountains (see figure 1).

Taxonomically speaking, the predominant pinyon-juniper (p-j) species of interest endemic to various areas are summarized in the table below although many other Pinus and Juniperus species are indeed endemic throughout the areas specified within the table.

Common Name	Scientific Name	Location	Ref. No.
Double-leaf Pinyon	Pinus edulis	Arizona	10,61, 132
		Colorado	24,25,26
		Nevada	85,61
		Utah	78,61
		New Mexico	79,61
Single-leaf Pinyon	Pinus monophylla	Arizona	10,61, 132
		Colorado	24,25,26
		Utah	78
		S. California	61
Common Juniper	Juniperus communis	Colorado	25,26
		Utah	5
		Oregon	11
Utah Juniper	Juniperus osteosperme	Arizona , Utah	29, 125, 132

Ecology in P-J Areas

Pinyon-Juniper areas are typical of the following climatic, physiographic, and edaphic conditions.

a. Long dry summers, cold winters with limited moisture (11)

b. Elevations of 5000-7000 ft with P. edulis predominating about 6800 ft (32)

c. Annual precipitation ranging from 10-13 inches in Oregon, Utah and Arizona (11, 78)

d. Soils ranging from rocky soils overlying basaltic lava with low organic matter content to sand and clay soils (11, 36, 48).

e. Temperatures ranging 105°F to -36°F in Oregon (11), and 28.9°F to 68.5°F in Arizona (32)

f. Endemic to the Sonoran, and Great Basin Deserts as well as some non-desert areas (see figure 2)

There has been a lot of work reported on the soil wettability in P-J stands throughout the west (12, 34, 38, 43, 79). These reports indicate that soil wettability is a function of organic matter content of the soil, soil type, management practices, overstory and understory plant density, and soil depth. Through discussion of these factors will be discussed in later paragraphs.

Ideally speaking, scientific judgments by forestry and related officials are based on biological information. The following discussion will involve a summary of information relative to basic biological research in P-J communities.

Biological Research Summary in P-J Communities

Numerous reports (27, 31, 33, 39, 45, 49, 51, 57, 58, 59) summarize the type of animal wildlife in the P-J communities. The location of the various mammals depends upon the elevation, plant type, understory and overstory cover found in the different P-J ecosystems. The major flora consists of various rodents such as rock squirrels (Spermophilus variegatus), grasshopper mice (Onychomys leucogaster), ord kangaroo rat (Dipodomys ordi), desert harvest mice (Reithrodontomys megalotis) deer mice, wood rats, and other species.

Each of the above named rodents are endemic to certain regions relative to climate and plant flora. An important point to raise at this time would be to discuss the effect of P-J management to rodent populations in different plant communities within the P-J areas; however, these points will be made in the management section of part-I.

As stated in a previous paragraph, basic biological research is important to forest managers and officials. The paragraphs to follow will attempt to delineate biological findings relative to the P-J communities.

It has been established that P. edulis and certain juniper species grow very slow. Myer's (5) work concerning Utah Junipers demonstrated that over a 20 year period Utah Juniper, Juniperus utahensis, had an average annual growth increment of 3.5 cubic feet, and a volume increase of less than 1 cubic foot. Furthermore, juniper height usually averages 30 feet at higher altitudes and less than 30 feet at lower altitudes (78).

Although 29% of the P-J type occurs on unstable geologic formations in New Mexico and relatively poor soils in other states (6), they usually occupy a lot of territory. Merkle (32) reports that both P. edulis and Juniperus species occupy 60% of the basal area in Grand Canyon, Arizona. Twenty-two percent of New Mexico forest lands (17.2 million acres) is inhabited by P-J type (6). Chapman's work demonstrates that P. edulis increases in diameter as it ages; its height starts to level off after 100 years and growth is rapid in deep soils capable of storing adequate moisture (79).

In the southwest, research on rocky mountain red cedar (J. scapulorum), pinyon pine and one seed juniper has shown that J. scapulorum exceeds P. edulis and J. monosperme in growth diameter per decade by .08 and .12 inches respectively (80).

Research involving understory cover is important for range and watershed officials in their attempts to design good management programs. The understory vegetation will vary according to the type trees (whether pinyon or juniper) (30), location of the P-J community (30,34,48,83), and stand density (90, 136, 137).

Arnold's study (30) demonstrated that different types of understory cover were found around J. monosperme at different distances from the base of the tree. His work showed that no vegetation existed immediately at the tree base; snake weed (Gutierrezia sarothrae), and wheatgrass (Agronpyron smithii)were found further out from the base and blue grama

and wheatgrass predominated as understory cover furthest from the tree base.

Studies in Grand Canyon, Arizona have shown that understory vegetation was quite sparse with the predominant species being Festuca arizonica (32); however, northern Arizona studies indicated that blue grama is the predominant species in juniper areas (36).

Studies in Utah indicate that desert shrubs, forbs and grasses such as Artemisia tridentata, A. noca and species of Festuca, Orzyopsis, Agronpyron and Elymus exist as predominant species (83).

Several factors besides location will determine the type understory as well as the density of understory in a P-J community. One of the main factors is competition for moisture (28). The classic case of competition involves juniper root competition with blue grama. Jameson's work indicates that this reduction in forage cover was due to shading, rainfall interception, phytotoxic root exudates, water and mineral competition and litter-with litter being the main cause of blue grama reduction (28).

The other factors have been substantiated by other investigators (12, 29, 36, 78, 90). Johnsen (36) has demonstrated that blue grama is very intolerant to shade; although when coupled with favorable factors, shading conserves moisture and benefits forage production. Thin-layer chromotographic analysis of J. osteosperme roots, rhizosphere, and surface soil demonstrated the presence of active growth inhibiting substances which when further analyzed proved to be polymers and

monomers of leucoanthocyanidin and catocin (29).

Stand density is one factor that can severely limit understory cover. Management criteria such as thinning has enabled sufficient forage cover in P-J communities (90).

As previously indicated, forage may be quite limited if some edaphic factors are absent. Soils low in organic matter, thin A horizons and primarily pumice sand and gravel, are poor forage producers (48).

Previous Management Practices in P-J Areas

Increase use of public lands by ranchers for grazing practices has resulted in intensive management efforts on the part of foresters to make these areas suitable for grazing, and recreation.

The conversion of P-J woodlands into grasslands for ranchers has been done by such techniques as cabling, burning, thinning, single chaining, double chaining, and windrowing. P-J conversion serves a three-fold purpose: reduction of soil erosion, increased wildlife forage, and increased forage available for livestock (70).

All of these management methods are neither biologically nor economically beneficial, although some have been proven to be quite effective and somewhat beneficial to P-J communities.

Good management practices should strive to do the following:

a. obtain maximum kill of all trees desired
b. result in increased soil wettability
c. cause increased understory cover
d. protect wildlife instead of upsetting the overall wildlife balance
e. support beneficial understory cover
f. increase soil moisture holding capacity with a corresponding decrease in soil bulk density and compaction

Aro's studies (1) involving conversion of P-J woodland to grassland have delineated several facts with reference to methods. The following facts summarize his studies:

a. Cabling or chaining is probably the best method for uprooting dense stands of old P-J trees, but cabling slips over small trees (10 ft) and merely tips many intermediate size trees. Kills range from 50-80%.
b. Burning does not allow the same high degree of site selection and treatment that windrowing does.
c. Although single chaining enables a 50-80% chance of kill, the amount of forage that results after chaining is very poor (100-300 lbs/acre of dried grass).
d. Double chaining is better than single chaining by both respects offering a 95-98% kill and 500-800 lb/acre harvest of dried grass.
e. Fire gives nearly 100% kill and offers tremendous understory forage recovery of 500-1300 lbs/acre.

f. Windrowing offers a 95% kill and forage recovery of 500-1000 lbs./acre in every instance.

The U. S. Forest Service's study involving cabling of Utah juniper indicated that total herbage production, particularly forbs and half-shrubs, doubled the second post treatment year but dropped back nearly to pretreatment levels during the third and fourth post treatment year. In additon, no meaningful changes in deer habitat and deer use was observed.

An obvious advantage of management is to increase the amount of acreage per cow for grazing purposes. Killough (20) reported that conversion practices caused the weight of yearlings to increase on an average 18 lbs. per animal; labor reduced by a factor of .1 per month, and an increase of $112 per section or $.18 per acre occurred. Copper (41) reported that the present average net land return from grazing, after deducting costs of fire protection and administration in the salt river watershed, Arizona estimated 6.5¢ more per acre after conversion. It has been shown that good grazing depends upon the ratio of the concentrations of palatable to nonpalatable plant species in the new understory; hence cattle weight gain from grazing will depend upon this added factor (39, 49, 50, 131).

Although, this is an important fact, the forest managers must be sure that overgrazing does not occur. The practice of overgrazing causes among many things, leading the soil to isolation, evaporation, and erosion; hence, the soil leads to greater dessication producing xerioc conditions (78, 138).

Cain (40), has done extensive work concerning the effects of chaining, and windrowing on various edaphic and physiognomic characters in P-J areas. The following facts summarize his studies:

a. Chaining causes a tilling-type action resulting in an excellent seedbed.

b. Piling the trees in front of the chain provides additional soil scarification and aids in covering seed; however, larger piles of trees tend to cover seed too deeply.

c. Watershed cover was increased by converting the vegetative cover from a canopy cover to a more desirable basal cover and increasing ground litter.

d. The wildlife habitat was improved by establishing an assortment of plant species needed to provide a variety in nourishment.

e. Although windrowing and burning the debris is frequently done to remove unsightly debris from chained areas, Cain states that this practice is considered undesirable because piles of debris left after chaining offer excellent cover for wildlife and watershed protection.

f. Economically speaking, the practice of windrowing and burning is too expensive for practice on low productive rangelands.

Plumber (23) reports that channel cutting as a management tool damages sedimentation of rivers and streams and causes increase runoff from summer storms.

As a matter of management criteria, the forester should evaluate his site, and plan his reforestation or revegetation program before chaining a site (21, 46). Packer (46) reports that for good sites, wheatgrass should be planted with the aim of obtaining at least 70% cover and a considerable larger cover percentage on less favorable sites. In addition to these facts, the forest manager should consider direct seeding in an attempt to minimize depredation by rodents (42).

The forester's management method obviously depends upon his intended use of the land after conversion (18). If the forester attempts to manage in hopes of raising Christmas trees, using juniper for fence posts, harvesting cordwood or nuts, his silvicultural regeneration practices must fit his needs.

One concern to economists would be the cost of certain management practices, especially chaining. Miller (19) has done a study depicting the cost of clearing an Alligator juniper watershed with saws and chemicals. He reports that this form of management practice was higher ($38.57/acre) as compared to bulldozing and burning as an alternative method ($25/acre). The table on the following page lists the current figures for chaining by state (70).

	1972		1973-1977	
State	Acreage	Estimated Cost ($)	Acreage	Estimated Cost ($)
Arizona	none	-	12,500	150,000
Colorado	none	-	54,900	549,000
Idaho	1,200	15,825	4,400	51,200
Nevada	780	11,766	8,650	115,000
New Mexico	none	-	170,700	not determined
Oregon	850	17,074	850	27,796
Utah	none	-	281,900	3,382,800

Total acreage chained to date plus that planned to be chained-----506,730.0

Considering 60,000,000 acres of P-J type falls in public domain and present, past, and future chaining will be done on public domain, the percentage acreage chained is .84% at a total cost of $7,072,265.00

Effect of Management Practices on Physiographic, Physiognomic and Edaphic Factors within the P-J Community

The population of rodents within the P-J ecosystem depends greatly upon the understory cover. In time, the wildlife within an area becomes stable; therefore the forest manager must plan his management plan such as to not create a disturbing balance in the area undergoing management. Below is a discussion on how management practices affect rodent populations in certain managed areas.

Turkowski (27) studied rodent population response in the Kaibab plateau of Arizona after P-J reduction. He reported that resident rodents increased and additional species of small rodents invaded the managed areas; the population of brush and pinyon mice decreased, and of those that invaded the area were rock squirrels, grasshopper mice, ord kangaroo rats and desert harvest mice.

Each rodent requires a different habitat. Some like sparsely covered areas; whereas, some like densely covered areas of understory. Of those requiring sparse understory cover are the kangaroo rats (31). Therefore management programs involving reseeding or planting seedlings will be in a little trouble since this mammal feeds on seedlings of pine and juniper as well as other forbs, and grasses (31, 33). Due to these facts rodent control measures should be a part of the overall management plan.

Spencer's research on rodent control (45) has shown that seed treatment with the rodenticide, tetramine works better than treatment involving

Effects of Management of [illegible] Populations: [illegible] and [illegible] Factors [illegible]

The population of rodents within the [illegible] depends partly upon the understory cover. In [illegible], the [illegible] because rapidly, therefore the [illegible] plan such as to not create a [illegible] management. Below is a discussion of how management practices affect rodent populations in [illegible].

Durkowski [illegible] rodent populations [illegible] of Arizona [illegible]. He reported that [illegible] increased and [illegible] numbers of small rodents invaded the [illegible] areas; the population of [illegible] and [illegible] increased, and of those that invaded [illegible] and [illegible].

Each rodent [illegible] a different [illegible]. [illegible] areas; [illegible] requiring sparse understory [illegible] (25). Therefore management programs [illegible] will be in a little trouble where this [illegible] of pine and juniper as well as other forms, and grasses [illegible]. [illegible] rodent control measures should be a part of the overall management plan.

Spencer's research on rodent control [illegible] has shown that seed [illegible] with the rodenticide, [illegible] works better than treatment involving thallium sulfate or sodium fluoracetate. He recommends a light broadcast application of poisoned bait about two weeks before seeding with rebaiting in the spring. Economically, he reports that helicopter seed spreading ($1/acre) is a lot less expensive than hand planting ($25/acre).

Gashwiler (51) studied small mammal levels in recently burned, logged as opposed to virgin forests. His results demonstrate the fact that burning will cause many rodents to invade green timberlands; the population of rodents increased after felling and logging; logging caused a moderate reduction of chipmunks, and shortly after the fire, the density was 2-3 times that of the virgin timber population with deer mice doubling in population one year after burning. It appears that logging, felling and burning may be a way of removing undesirable species of rodents.

Tenis (67) showed that logging invited greater numbers of white-footed and big oared mice, townsend chipmunks, dusky footed wood rats, digger squirrels, and brush rabbits within the area; whereas, logging decreased the number of trowbridged shrews, red backed mice, flying squirrels and shrew moles in the areas.

Ecological data demonstrates that deer mice invade brush fields and coniferous forests after burning or logging(69).

From these data it can be said that a successful management program depends largely on the forester's ability to design a program where

the resulting ecosystem is favorable. For example, if the forester converts P-J woodland into a forest nursery without proper rodent and deer management (68), his seedlings will not mature; on the other hand, proper rodent and deer control will aid toward a successful program.

Management practices also affect the outcome of soil hydrolic factors and herbage yields. Since soil is the medium within which all forest and range flora exist, improper management practices will drastically affect the physiognomy of the ecosystem. The following discussion includes facts which explain the effect of certain management practices on the edaphic characteristics of the P-J community. It has been shown (14, 38) that cabling juniper causes a reduced surface waterflow of .09-27 inches annually; this reduction due to pit formation is quite significant when one considers the amount of rainfall in these semi-arid environments (11,78). Since the practical elimination of cabling as a tool to achieve P-J conversion, soil infiltration rates have been studied by numerous investigators (17, 37, 38, 43, 56, 86, 91, 92, 129, 134). In some cases P-J conversion does not increase infiltration and erosion of soils (17); whereas, other investigators (86, 91, 38) show that soil infiltration and erosion depends upon the method of management. Gifford, one of the nation's leading hydrologists with reference to P-J chaining, reports that mechanical activity such as chaining and windrowing significantly increases permeability due to its form of "plowing" action (37, 86, 91). Such activity must increase noncapillary porosity while

decreasing bulk density (43, 91). However, other methods such as double chaining and leaving the debris in place do not cause significant increases in soil permeability. In addition, logging as a management practice has been demonstrated to decrease soil permeability resulting from compaction (56).

It turns out that burning whether it be prescribed or not affects the soil properties tremendously. Austin's work (47) has shown that burning of logged slash pine areas reduced the average moisture holding ability of the top ½ inch by 33.7%; furthermore, he reports that burning releases quite a bit of phosphorus, potassium, calcium, and magnesium with potassium being 166% higher immediately after the burn and 112% higher after two years in burned areas as opposed to virgin areas. Calcium released was 830% but reduced to 327% after two years. Magnesium was 327% higher in burned soil but returned to normal after two years. Such sudden availability of nutrients cause severe changes in soil pH. The pH of the top ½ inch of soil in the previously described experiment was quite alkaline (pH of 7.6); whereas, the normal site had a pH of 4.5. After two years the pH on the burned site reduced to 5.7.

Austin's work has been substantiated by other investigators. Fuller (63), Vlamis (88), and Packer (110) reported that fires increase the content of available nitrogen, phosphorous, sodium, potassium and calcium as well as the soil pH on burned soils. In addition, Fuller reports that the heat caused clay colloids to dehydrate thereby destroying the soil surface layer structure. The burns also increased water

runoff and erosion. In addition, Krammer (34) and Packer (110) reported that fire drastically reduces soil wettability in that the upper layer of soil becomes hydrophobic. The hydrophobicity is due to organic materials from burned plants.

Weaver (66) presents an argument for the ecological impact of using fire as a management tool. He concludes that although uncontrollable fires are totally unwarranted, a "prescribed" or control fire needs more study. Since this publication, several investigators have demonstrated the effects of prescribed fires on understory cover and grazing. Lemon (72), McConnell (77), Jameson (81), and Warlenberg (93) have shown that management of woodlands converted to grasslands increased the grazing potential, cattle gains, and understory cover (6 lb. increase for each 1% decrease in the tree canopy). Many of these effects are directly due to the resultant increase in soil temperature (92). The temperature increase the concentration of available nutrients, stimulates biological activity as evidenced by increased seed germination and carbon dioxide evolution (84, 87, 92), and decreases competition principally for sunlight and soil moisture (89).

It has been noted that prescribed fires as a management tool increases the amount of Galleta-Black Grama as well as other beneficial grasses in converted P-J woodlands (81).

Partial conversion of P-J woodlands by means of thinning increased the herbage yields (76, 77). Juniper removal in Utah increased the

yield of perennial grasses, most forbs, half shrubs and shrubs (15,16). In the case of Pinus ponderosa, thinning increases the rate of development for ponderosa pine seedlings (58,60,75). Further investigations indicate that clearing some areas increases the amount of water available for forage production while maintaining good soil water storage (95).

Sometimes it is desirable to remove understory cover to achieve a greater density of overstory cover (52, 74). In addition to these facts overstory growth is aided by thinning and deer management practices (53,73). Therefore, one's management practices definitely influences the resulting ecosystem in the particular P-J woodland of concern.

One of the most complete management and restoration programs has been done in Utah involving restoring big game range (97). The publication summarized soil types and general understory cover of the area. As in publications already listed (6,12,34,38,43,48,79), most of the soils throughout Utah are derived from sedimentary rocks, including limestone, shale and sandstone; however, areas in southwestern and western as well as some areas of northern Utah are developed on granite, basalt and acid lava. Because a portion of this study involved P-J type areas, this study is of particular interest of the Bureau of Land Management (U.S.D.I.).

Many of these areas now support vegetation; however, they do not provide satisfactory forage or watershed protection. Among these areas are the

Pinyon-Juniper type. In order to restore these areas for suitable range improvement, indicator plants were set out and selected on basis of growth with reference to the amount of precipitation, watershed protection, palatability, and food resources for birds, game and rodents during winter months.

The methods employed for site clearance included, cabling, double chaining, bulldozing and disking. The method used on a particular site was relative to amounts of existing understory and overstory vegetation and the preference for removal of either or both if not all of the understory and overstory vegetation.

This report summarizes the methods for seeding areas cited for restoration. Employment of direct seeding by hand, drill, or broadcasting (by air or man) was relative to the size of the site, time of the year, and the economics involved. Seed treatment methods prior to seeding were also summarized. The type seed used determined whether stratification or scarification by physical or chemical means was to be employed.

In P-J sites, anchor chaining twice over in opposite directions proved to be satisfactory. In areas of very little desired understory coverage, planned burning was employed.

The planting procedures for new understory coverage depended upon the management procedure. When chaining or cabling twice over was done, broadcasting seed between chaining or cabling operations was done so as to cover the seed by the second treatment. For seeding areas broken

in patches aerial seeding with helicopters was employed. The table (next page) summarizes the species recommended for general and special purposes in pinyon-juniper type chained areas.

The following additional species may be substituted for general and special purposes in the juniper-pinyon type.

GENERAL USE

Grasses:
- Bearded or beardless bluebunch wheatgrass
- Bottlebrush squirreltail
- Bulbous barley
- Bulbous blue grass
- Great Basin wildrye
- Indian ricegrass
- Orchardgrass
- Hard fescue
- Sheep fescue
- Siberian wheatgrass
- Sulcata sheep fescue

Forbs:
- Lewis flax
- Nevada showy goldeneye
- Nuttall lomatium
- Pacific aster
- Showy goldeneye
- Sicklepod milkvetch

Shrubs:
- Nevada ephedra
- Little mountain-mahogany
- Squaw-apple
- Tatarian honeysuckle

Special Use

Grasses:
- Meadow brome
- Mountain rye
- Tall wheatgrass
- Winter rye

Forbs:
- Bouncing-bet
- Bramble vetch
- German iris
- Cutleaf balsamroot

SPECIAL USE (continued)

Forbs (continued):
- Eaton penstemon
- Gooseberryleaf globemallow
- Louisiana sagebrush
- Nevada lupine
- Oneflower helianthella
- Palmer penstemon
- Parry goldenrod
- Silky lupine
- Smooth aster
- Tarragon sagebrush
- Thickleaf penstemon
- Toadflax penstemon
- Vegetable-oyster salsify
- Wasatch penstemon

Shrubs:
- Apache-plume
- Arizona cypress
- Black common chokecherry
- Blueberry elder
- Common lilac
- Desert peachbrush
- Fringed sagebrush
- Gardner saltbush
- Longflower snowberry
- Martin ceanothus
- Mountain snowberry
- Peking cotoneaster
- Rocky Mountain smooth sumac
- Roundleaf buffaloberry
- Russian-olive
- Siberian peashrub
- Skunk bush sumac
- Spineless hopsage
- Spiny hopsage
- Wyeth eriogonum

The seeding and transplanting methods for establishing the P-J plant substitutes are summarized in detail in the publication. In addition, techniques for collecting, cleaning and storing seeds are also summarized in the publication.

In the spring of 1969, U.S.D.I.'s Bureau of Land Management incorporated much of this meaningful data into a manual which summarized most of the aspects of Pinyon-Juniper (120). The manual included biological as well as silvicultural and managerial aspects.

The manual broke P-J regions into two areas, namely, the northern part (Nevada, Utah, Colorado) and the southern part (Arizona and New Mexico). It turns out that the climatic differences in these two areas definitely influence the management procedures. BLM's data indicates that Pinyon pine grow on soils that are quite coarse and rocky; whereas, juniper grows on much finer and drier type soils. These facts in addition to many others also influence the reforestation program after conversion.

In P-J conversion, it appears that chaining and windrowing, as previously mentioned caused a greater percent kill. Understory grasses, shrubs and forbs recommended for reforestation are found in the table on the following page.

At this stage, the BLM manual has summarized the efforts of many researchers into a concise proposal for Pinyon-Juniper management in the west.

GRASSES

Agropyron cristatum
Agropyron desertorum
Agrropyron intermedium
Agropyron trichophorum
Elymus junceus
Agropyron smithii
Agropyron spicatum
Bromus inermis
Elymus cinereus
Dactylis glomerata

SHRUBS

Cowania mexicana
Putshia tridentata
Purshia tridentata X Cowania mexicana
Putshia glandulosa
Artemisia tridentata
Artemisia nova
Artiplex canescens
Chrysothamnus nauseosus
Symphoricarpos oreophilus
Eurotia lanata
Ephedra viridis
Cercocarpus montanus
Amelanchier utahensis
Cercocarpus ledifolius
Ribes aureum
Prunus fasciculata
Lonicera tartarica
Sambucus coerulea

FORBS

Sanguisorba minor
Medicago sativa (Rambler, nomad, ladak)
Astragalus cicer
Melilotus officinalis
Hedysarum boreale
Balsamorhiza sagittata
Penstemon eatoni
Penstemon palmeri
Astragalus falcatus
Astragalus stenophyllus
Linum lewisii
Sphaeralcea grossulariaefolia
Lupinus sericeus
Lupinus caudatus
Medicago falcata
Helianthella uniflora
Balsamorhiza macrophylla

In this section, I have attempted to summarize various facts concerning the general P-J ecosystem emphasizing facts relative to edaphic, physiographic, and physiognomic characteristics influencing, and effected by management principles.

Part II of this paper will summarize current research in the area. The data for Part II was obtained from knowledgeable people actively doing research in P-J communities.

PART II

I. Observations in the Phoenix and Flagstaff, Arizona areas with reference to location.

II. Current field research being conducted at the Beaver Creek Watershed near Flagstaff, Arizona.

III. Current field research in Utah conducted by Dr. Fred Gifford of Utah State University.

IV. Comparison of current research performed by the Forest Service (Beaver Creek) and Dr. Gifford and its applications as demonstrated by the Sheepcreek watershed - Utah.

During the time interval of July 10-12, 1972 the author observed the locations of Pinyon-Juniper type species in the Phoenix and Flagstaff, Arizona area. Due to the elevation, no apparent overstory of P-J type species occurred within the Phoenix area.

The Juniper belt was observed to begin at an elevation of 3790 feet in the vacinity of Cordes Jct., Arizona and increased indensity further north toward the Beaver Creek watershed area (see figures).

The Beaver creek watershed is a multiple acreage plot divided into twelve or more different experimental watersheds of varying acreages located in the Coconina National Forest.

Dr. Warren Clary (U.S.D.A.-Forest Service) was the guide and scientific reference for the tour. The watershed tests involved evaluating water yield, understory recovery, wildlife use and other facts regarding mechanically treated plots of Utah Juniper, Alligator Juniper, and Pinyon Pine (see figures). The test revealed the following results (139):

A. Alligator juniper dozed over and chained produced no effective vegetative cover. Aerial seeding on the site wasn't successful. when cabled (1958) and aerial seeded, the resulting understory was not useable to wildlife. The basic soil type was basaltic volcanic with some cinder and heavy clay soil.

B. Utah juniper treatments (1964-1969 average data)

   1. Cabling with the slash burned followed by seeding with lovegrass and sideoats grama resulted in an increase of 46 lbs/acre of preferred forbs, 51 lbs/acre of grass and 1,111 lbs/acre of herbs.

2. Chemically treated plots sprayed with a 2-4 dichlorobenzene derivitive at a rate of 2.5 lbs/acre resulted in significant increases in water yield, an increase of 205 lbs/acre of perennials, and 12 lbs/acre of preferred forbs for deer. During 1970-1971, an increase of several hundred pounds per acre of preferred forbs occurred. Sediment studies demonstrated no detectable trace of spray 1/4 mile down stream from the floom. Chemical analysis at the site of the sediment and runoff floom necessitated measuring of of the chemical trace in parts per billion.
3. Saw treatment (clearcutting) resulted in a 30% increase in forbs.

C. Ponderosa Pine Treatments.

1. Clearcutting followed by windrowing resulted in good forage, grass cover, low sediment and runoff and increased deer usage.
2. 1970 thinning resulted in a 40% increased in water yield.

Dr. Fred Gifford of Utah State University's Range Science Department has research plots on two sites in southern Utah. This section of the paper summarizes his research efforts.

The study plots located on the Maverick Point Resource Conservation area located near Blanding, Utah involved analysis of sediment and runoff watershed values for chained sites with windrowing and debris in place. The study was initiated in the fall of 1967 and immediately after chaining, crested wheatgrass was drilled seeded in the fine, sand-silt type soil.

The first group of pictures show the results of the windrowed sites. A portion of the windrowed area was fenced off and made unaccessible to cattle. The data collected involved average annual precipitation, water run off and air permeability for porosity data.

This protected area showed higher water infiltration and less sediment production. Grazed areas showed more sediment and runoff. Other data collected from this site demonstrated that grass production in chained areas with debris in place was less than in protected areas, and overgrazed, reseeded grass covered areas invite P-J to come back to its initial potential.

Site 2-5 year plots

These sites involved blocked, nonaccessible, .1 acre plots (120 x 43.5 x 100 ft.) for the purpose of obtaining sediment and runoff data. The sites were divided into several untreated areas, chaining followed by windrowed areas, and areas where P-J was chained with debris left in place. The following results were obtained:

A. Continuous recording equipment for sediment and runoff analysis monitored sediment and runoff values after each rain. The data demonstrated that the windrowed areas had more sediment and runoff than both the control and debris in place plots. The debris in place sites had the least amount of recorded sediment and runoff; whereas, the windrowed sites had twice as much sediment runoff than the controlled sites.

B. Soil moisture analysis indicated that soil moisture retention was greatest on sites that were chained with debris in place and least on windrowed sites (see figures).

C. Cryptogams covered the .1 acre plots. Evidence demonstrates that cryptogam cover increases infiltration; however, no current techniques exist that definitively measure either cryptogam cover nor its total contribution to soil water infiltration.

D. Sites with debris in place demonstrate that pinyon pine and Utah juniper reestablishes itself quicker than on both controlled and windrowed sites (see figures).

E. Debris inplace sites resulted in 20-50% litter cover and 30-35% grass cover such that 60 or more percent of the area had ground cover.

Gifford's study sites near Milford, Utah involves the identical type work showing nearly identical results as the sites located near Blanding, Utah.

Although, the basic soil type at the Milford site was drastically different from the soil at the Blanding site, sediment and runoff values were about identical in value and exact in both study sites.

These .1 acre runoff plots had a basaltic type soil whose soil profile was 34-35% by weight in rock and fines with 4-8 inches of clay. Furthermore, the Milford study sites had greater canopy cover (18-20%) and a much more diverse understory cover of big sage brush, black sagebrush, blue grama and indian ricegrass. Pictorial accounts are found on the following page.

Another interesting research account involves sap velocity studies. Thermocouple probes were placed in _P_. _edulis_, _P_. _monphylla_ and _J_. _osteosperme_ trees and a pulse of heat introduced. Sap velocity measurements indicated higher upward sap velocity measurements than downward rates for all trees tested. The results indicate that sap velocity rates for juniper species growing on drier soils was higher than pinyon pine types; conversely, Pinyon pine types show higher sap velocities than juniper species when growing on wetter soils. These data may explain why juniper species usually invade new areas and are established earlier than pinyon pine types; however, conclusive data has not been obtained to substantuate this hypothesis.

Both the Beaver Creek Watershed and Gifford studies are quite significant. The Beaver Creek study outlines details relative to understory response after chaining projects and its use by wildlife. Gifford studies outline detailed hydrologic values on chained sites followed by both windrowing and debris in place. Therefore, both of these studies are quite important in determining the environmental impact of mechanical methods of P-J manipulation.

The Sheepcreek Watershed project near Cannonville, Utah demonstrates good conversation of sagebrush areas to crested wheatgrass with the appropriate retention dams (dikes) built (see figures). Hence, data and techniques obtained from chained sites can be used in planning other watershed type research in range management.

PART III

I. Current Recommendations Based On Published Literature

  A. Present recommended practices

  B. Advantages and disadvantages of these recommendations

II. Professional Recommendations

When one attempts to recommend certain facts relative to some programs, he must make a through review of the old as well as the most recent recommendations. Futhermore, the strength of the recommendations usually depend to a great extent upon the importance of the commodity or produce involved.

Recent reports have indicated that Pinyon-Juniper woodland types, specifically the pinyon pines (_P. edulis_ and _P. monophylla_) are very important commercially in the western United States. Economic studies have revealed that _P. monophylla_ is in great demand in the western christmas tree industry (116); with an average sale price of $4.00 per tree, _Pinus_ species made up 43.6% of the total christmas tree sales in Utah in 1960 and 56.0% of the sales in 1961 (117,118); in 1965, Pinyon trees made up 1% (465,000) of the total christmas tree sale in the United States (118), and Pinyon species are commercially important in the charchol briquette, and firewood industries of Utah, California, Nevada, and Arizona (114, 115, 119, 121). With these few industrial outlets for the pinyon-juniper areas, it is therefore imperative that the woodlands be managed in order to keep the P-J woodland ecosystem balanced.

Several investigators (discussed below) have found facts quite relavant to P-J woodland management. One can argue the subject of management in many ways. Some scientists (8) believe that management should bring more biological control agents under its umbrella; whereas, others draw their attention toward the physiological effects of our

current management practices on the ecosystem involved.

Particular attention to the effects of currently used practices on the soil has delineated the following facts:

a. Windrowing causes large amounts of sediment and runnoff; whereas, double chaining causes a small amount of sediment and runnoff (22).

b. On steep slopes, the root systems of P-J types among others help stabilize or increase the shear strength of the shallow unstable soils (109).

Recent investigations (63,103) have shown that the endomycorrhizae are important in aiding nutrient absorption into tree roots. Data have been gathered which shows that burning decreases the population of these Mycorrhizae. Besides this finding, burning has been suggested as a deterrant to good tree production as elucidated by Debell (98). He concludes that burning of forest trees release nitrogen gas into the air and only a minute amount is returned through precipitation. Since these soils are relatively unfertile, removing this important potential soil resource is not good.

In a management program, particular attention is always given to forest regeneration after conversion. For purposes of grazing, anything that limits production of understory grasses, forbs or shrubs is not good.

Some reports have suggested that tree litter, and logging residue severely hinders certain understory specie production. Other reports (101, 102) have confirmed the facts that where litter is removed after thinning practices, significant increases in understory cover occur.

Furthermore, regeneration efforts should be applied promptly after logging. Too long an interval results in vegetative growth that competes with seedlings and provides cover for hares and mountain beaver that feed on young seedlings (122).

Some foresters and managers have stated that heavy grazing on converted P-J woodlands have caused severe understory removal; however, one should bear in mind that many other factors enter and reduced grazing may not necessarily increase understory cover (100).

Several investigators have spent time determining growth requirements for reforestation programs. Although fertile soils as a rule produce greater seed crops (35, 65), some grass species will grow in P-J areas containing unstable, rocky soil. Lehmann lovegrass becomes established more quickly on semi desert range than any other perennial grass (99).

Not all management attempts are geared toward conversion of P-J woodlands to grasslands for grazing purposes. In many cases, reseeding or transplanting the parent trees is done. With the onset of new industrial uses for pinyon-juniper types, some areas will undoubtedly have to be reseeded or transplanted to P-J types to replace the harvest trees. Genetic (101) and botanical research (51, 64, 71) have shown that soil temperatures less than 15° C restrict root growth of transplants; newly initiated roots require 150 cold nights of exposure in _P. ponderosa_, and photoperiods higher than 16 hours aid seedling growth. These facts clearly suggest that the spring and summer months may be the best time to transplant P-J type species in managed areas owing to the long, hot, days and cool to cold nights.

In seeding, care should be taken to insure an adequate crop. Nontreated seed may become the target of rodents, therefore, chemically treated seed is usually employed. A new chemical 1,2,3,4,10,10, hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a octahydro-1,4,5,8-endo-endo-dimethanonapthlene, trade name Endrin, is used to impregnate and coat pine seed for revegetation planting purposes (111,113,122). Seed stored at room temperature or at subzero temperatures are viable for up to 3-4 months (112).

Some of the facts presented in this paper so far are contradictory (e.g. in some cases use of fire as a management tool is good; whereas, in some cases fire is bad). One major conclusion can be drawn: MANAGEMENT OF P-J WOODLANDS FOR WHAT EVER THE INTENDED PURPOSE DEPENDS UPON THE USE OF THE LAND AFTER MANAGEMENT, THE DESIRED ECOSYSTEM RESULTING, AND THE CURRENT INDUSTRIAL MARKET.

In view of these arguments the Dept. of the Interior's Bureau of Land Management under the leadership of the Utah State Office of B.L.M. has taken the responsibility of writing an environmental impact statement on the subject of Pinyon-Juniper chaining. This umbrella statement (written according to BLM's manual no. 1792 (140)), will be written with the purpose of either justifying or advising discontinuance of Pinyon-Juniper chaining.

The seven member interdisplinary team is composed of specialist representatives of four of the Western State Offices and the Denver Service Center. The author attended the first meeting held on 21 July 1972 at the Utah State Office. At this meeting it was decided that each team member would be held responsible for writing a portion or portions of the environmental statement. As of to date the statement has not been finished, but its first draft is expected to be completed by January 1, 1973.

It is also important to recognize that future uses will suggest use of P-J lands for recreation areas, separate sites for christmas trees, firewood, charcoal and fence posts production areas.

Taking all these facts into hand, it is most important that the following stipulated recommendations receive attention.

The following recommendations are designed as principles for which should be considered toward any P-J management or woodland manipulation program:

The Management Concept

As we all know, total or partial conversion of any woodland species results in total or partial destruction of the converted resource; hence, the question of distinction is, "How does one determine when area needs to be totally or partially converted?"

In the case of privately owned land, the land owner converts his resources in the direction most advantageous to his economy. However, when one considers conversion or manipulation of woodland species on public domain, the problem of public pressure against governmental wishes will always cause some form of conflict. It is these issues upon which the responsible officials must meditate upon.

Therefore, one must understand what management is and be able to determine the type of program best suited for various areas. The remaining recommendations contain statements upon which responsible officials should consider in objectively planning meaningful forestry programs.

Recreation-Multiple Use Benefits

With the crowding of cities and suburbs, Americans have become more "vacation conscious" since most of America's scenic wonders are located in Western United States, management of P-J acreage in these areas must be of paramount importance.

There are a variety of recreation uses for P-J woodlands - amoung which are picnicing, nut gathering, free-use firewood, hunting, and road-side park rest stops. With these opportunities, management methods must take several forms. Double chaining followed by windrowing or debris in place will not make road side parks, picnic areas or nut gathering sites neither aesthetically pleasing or safe; whereas, hunting or free-use wood areas, are better suited by this form of management manipulation. Therefore, management officials must design other techniques such as thinning or prescribed burning followed by reseeding to convert some P-J areas for purposes of picnicing, nut gathering or road side park areas.

It is understood that P-J natural stands can't be converted for all recreational uses; therefore, the manager will need to access the conversion practice deamed most necessary for the areas in question.

Conversion Techniques

It is improtant for the forest manager to know the environmental impact of chaining, thinning and prescribed burning. It is important for him to know the effects of these techniques upon the soil and resulting aesthetics. In his concept of management, the forest manager must be able to assign a conversion techniques relative to the future use

of the area. The author would recommend thinning for areas where families gather for purposes of eating and playing. Chaining for conversion to grasslands is good for development of new pasture lands for ranchers, and burning should be the least used technique due to its effect on the soil and potential for resulting understory density. (See Part I).

Wildlife Aspects

In an attempt to manage or manipulate woodlands one must consider the effect of these practices on wildlife. When the forest manager speaks of wildlife, he must bear in mind both big game and small mammals. It has been shown (see part I) that various management and conversion methods definitely affect wildlife usage of the affected site.

Previous data also suggest that conversion of areas to grasslands by chaining followed by either windrowing or debris left in place will provide shelter for small mammals and grass, forbs and shrubs for all game types. Therefore, the manager must keep in mind that the resulting situation desired will determine the method he employs.

The author suggests that acreage to be converted into wildlife conservation areas for small mammals and big game be done by double chaining followed by leaving debris in place. As seen in the photographs (part II) regarding this type treatment, resulting grasses, and dead trees provide adequate food, shelter and protection for wildlife.

For hunting areas where adequate shelter and food for big game animals are desired, either double chaining, followed by windrowing or debris left in place will be suitable. These areas provide sufficient space for the hunter, and sufficient shelter and food for game.

Watershed Aspects

One of the most important aspects to consider when designing a forest management program is to consider the effect of the program on the resulting watershed values of sediment, runoff and water-yield.

Consideration must be given to flood potential, design for flood prevention and protection of wildlife. It is not a good practice to convert P-J stands on hills or steep slopes to grasslands because the time required to establish cover is not sufficient enough to merit the damage resulting during the interval from conversion to cover. Wind and rain storms would cause serious erosion thereby eliminating protection against flooding situations.

Any area once converted that continues to show increasing amounts of sediment and runoff is not good for the environment for this not only places wildlife in danger from potential flood but it is also aesthetically displeasing.

Conversion of P-J sites, whether totally or partially, should result in not only good (70%) cover but should also result in increased water yields. Current research demonstrates that double chaining with debris left in place increases water yield significantly over that found in untreated areas by a factor of two; whereas, double chaining followed by windrowing causes more sediment yield and runoff than an untreated site.

On these basis, the author recommends double chaining with debris left in place as the best practice for watershed management.

Range Aspects

Generally, the rancher and range scientists totally convert P-J acreage to grasslands for grazing purposes. Although this is the easiest, most economical, and fastest manipulative tool, the manager must bear a few facts in mind. Since double chaining followed by windrowing and burning the slash is the desired technique, decreasing water yields are expected. Burning the windrows would likely decrease rodent populations and thereby insure higher grass yields.

The main decision is whether to plant native or foreign grasses in the converted area. Monoculture plantings of crested wheatgrass has resulted in good cover; however, this is a bunch grass and decreased water yield limits its probable use as an effective cover. Planting rhizomatous or stolonaceous grasses would render faster cover and favorable water yields.

If native grasses are unpalatable, planting nonnative, easily adaptable grasses should be done. Since monoculture planting do not provide good long-term cover, a seed mixture containing bunch, rhizomatous and stolonaceous grasses, some of which should provide quick cover. After the seeds are coated with a rodenticide and fungicide, the seeding method employed should be one that provides even distribution.

Areas of Attention

Current research deals mostly with the soil hydrologic values resulting in P-J chaining projects. This research has been extensive and has yielded much needed data. The following discussion lists current information the author thinks desirable for a more complete picture of P-J management and manipulation.

Growth Studies

With increase use of Pinyon pine for christmas trees and firewood, studies need to be initiated which would render information relative to mass production of trees, varieties producing good shape for christmas trees, and P-J type species' potential for timber sale increase volume of P-J type in timber slaes, free use permits have increased (143). This fact indicates that future demands for P-J will increase and research growth studies would help meet these needs.

Wildlife Usage

In the interest of wildlife management, a detailed research attempt on how various management practices affect the wildlife composition

and population levels in P-J chained and unchained areas would be helpful. The effect of population levels and usage in manipulated P-J woodlands would be a good indicator toward determining protection benefits and usage by small mammals and big game in connected areas. Techniques for determining these data are published (see part I); hence, research efforts would be greatly simplified.

New Stands

In the area of woodland products such as christmas tree production, research work relative to conversion for production of new trees woudl be helpful. Theoretically, young trees with good spacing and ground cover for moisture should grow to healthy seedlings and trees. If indeed this is possible, it would be a good practice.

Studies indicate that double chaining with debris in place (see part II) aid easier establishment of P-J types. If after these seedlings are established, the debris is removed, and excellent opportunity for study would exist.

Prescribed Burning

As an alternative, cheaper method to chaining, prescribed burning should be tried. Previous reports indicate that burning is bad for the soil; however, a quick burn has been reported to cause favorable results (part II). These studies have been conducted in Ponderosa pine stands and no definitive word of this nature has been performed in P-J areas. If data demonstrate that this is a feasible practice then this technique would be a good alternative.

Increasing understory in P-J stands without total conversion: The greatest limitation to understory production is competition for and lack of moisture. It is theoretically possible that if moisture is increased in P-J stands by a slight reduction of canopy cover followed by construction of retention dams, understory cover should increase. This practice should reduce the need for massive conversion thus reducing forest management costs. Based on this justification, it would be advisable to conduct studies designed to determine the feasibility of this alternative to current conversion techniques.

The recommendation areas discussed,

1. The management concept
2. Recreation-Multiple Use Benefits
3. Conversion Techniques
4. Wildlife Aspects
5. Watershed Aspects
6. Range Aspects
7. Areas of Attention

if given attention should offer solutions for problems of not only management and manipulation of P-J woodlands but for other woodlands undergoing similar conversion practices.

PART IV

I. Summary

II. Acknowledgements

It is a basic principle of forestry programs to manage forest resources; however, huge acreages of these resources makes forest management seems impossible. This report was written in an objective view point examining most areas that affect and are effected by forest management programs.

When policies are initiated by certain officials which would affect vast acreages of resources, one mistake could cost millions of dollars. Hence, this publication is designed to inform forestry officials of the following:

A. The research information reported on P-J type species

B. The current research areas and emphasis

C. The current recommended practices

D. Recommendations for consideration

This outline is designed to allow the reader to obtain a good background on P-J types before recommended practices are emphasized. The author is not stating that previous practices have been neither wrong nor right; his thesis simply states that forest management practices should rest on both current and previous research information. Ignoring information is costly and a good forestry official should be aware of all aspects of a particular problem before stipulating mitigating measures.

The author would like to thank the Director of the Bureau of Land Management, the Washington Office Forestry Staff and the State Offices for their consideration. In addition, particular thanks is due Mr. Murl Storms (Chief, Division of Forestry - Washington Office) for designating the assignment, Dr. Fred Gifford (Utah State University), Dr. Warren Clary (Beaver Creek Watershed) and Mr. Lemare Mason (Soil Conservation Service - Utah) for their help in the field.

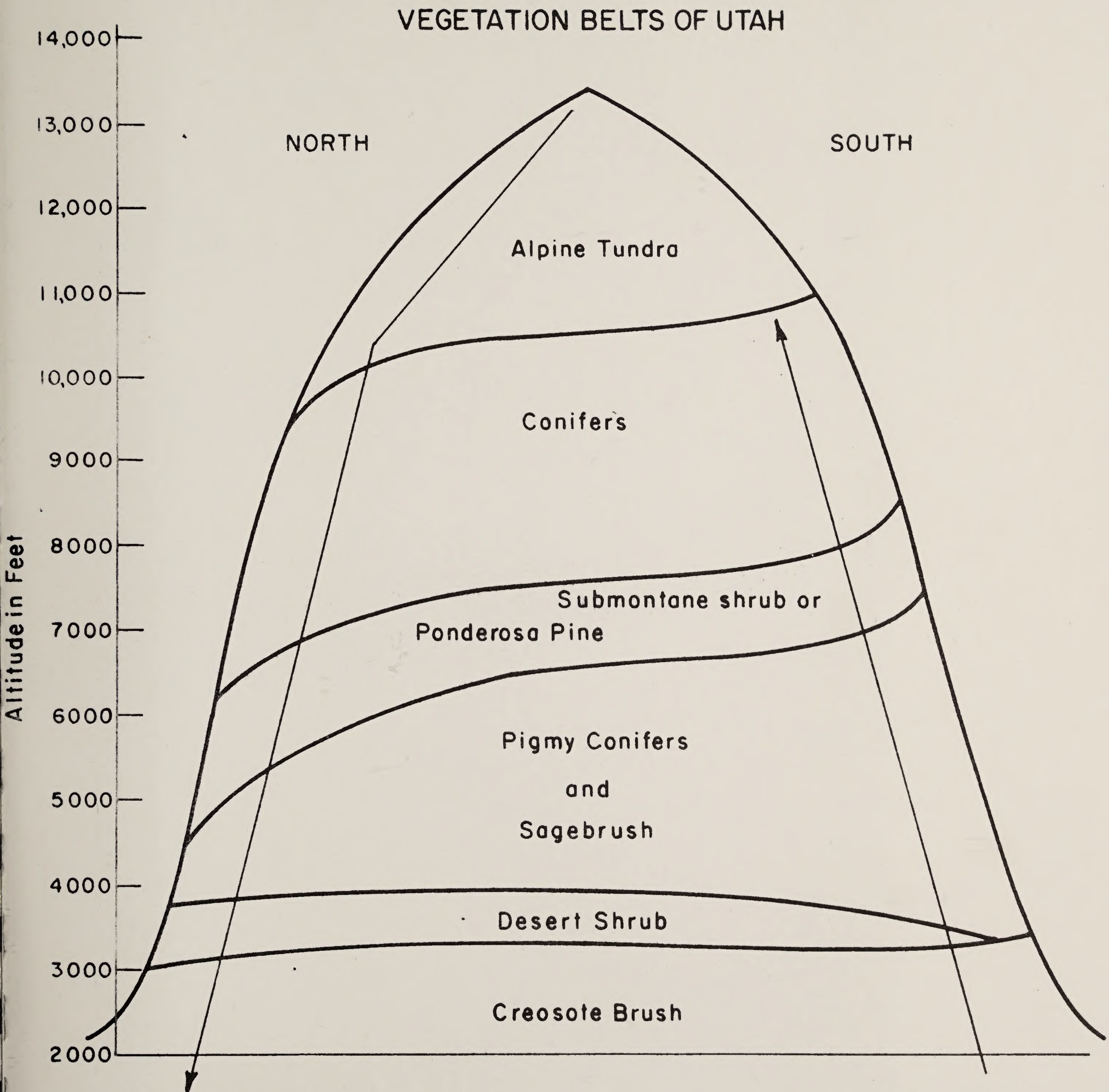


Fig. 1. A generalized profile of vegetation belts or zones in Utah mountains.

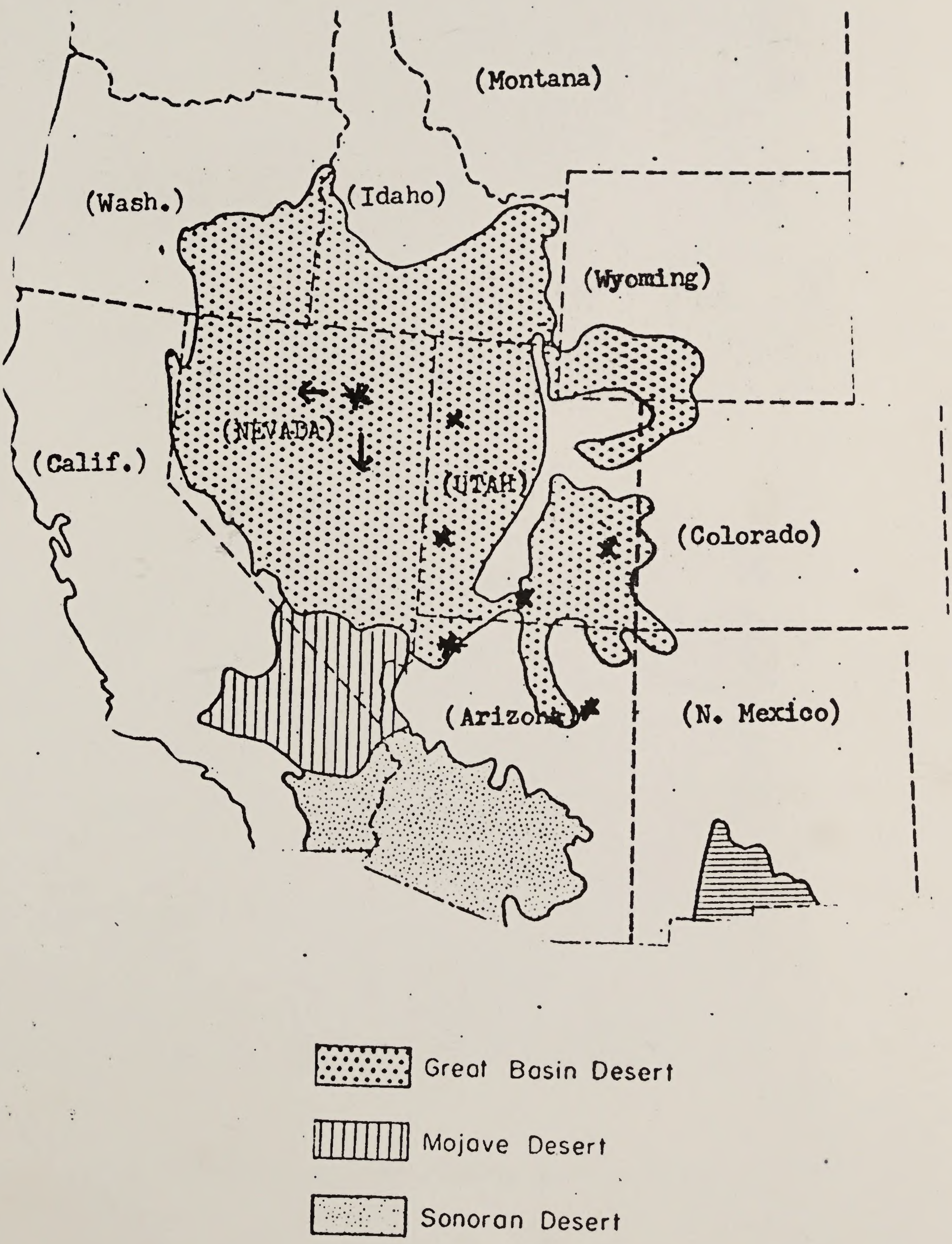
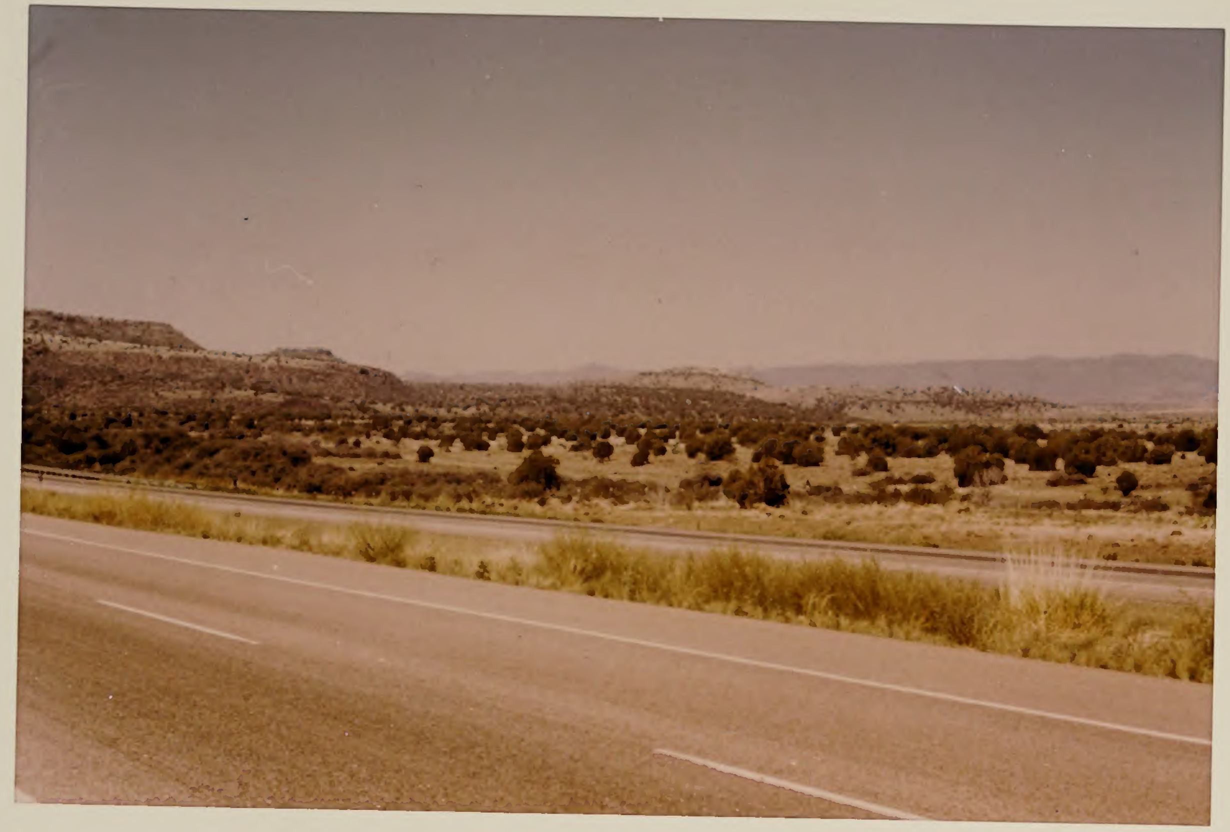
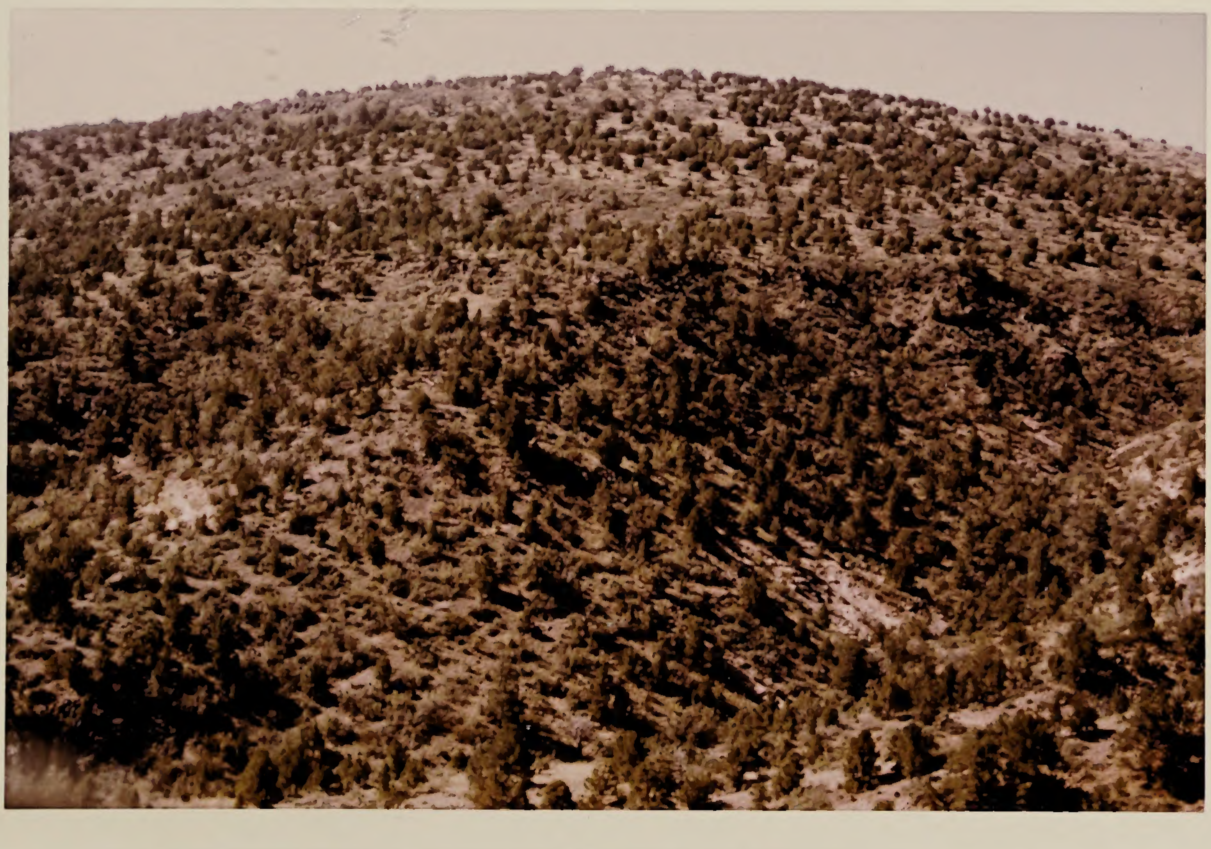


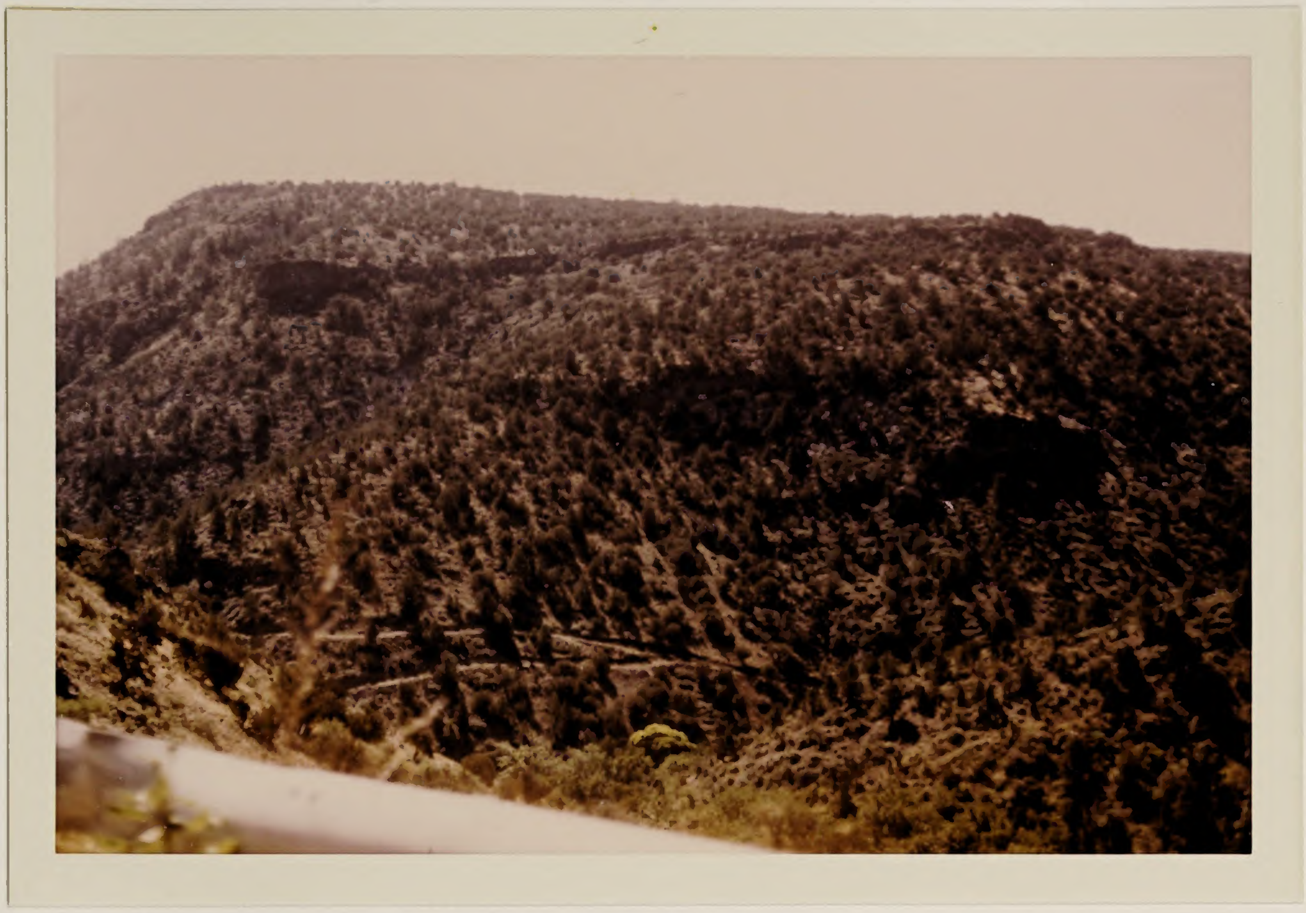
Figure-2
* P-J areas



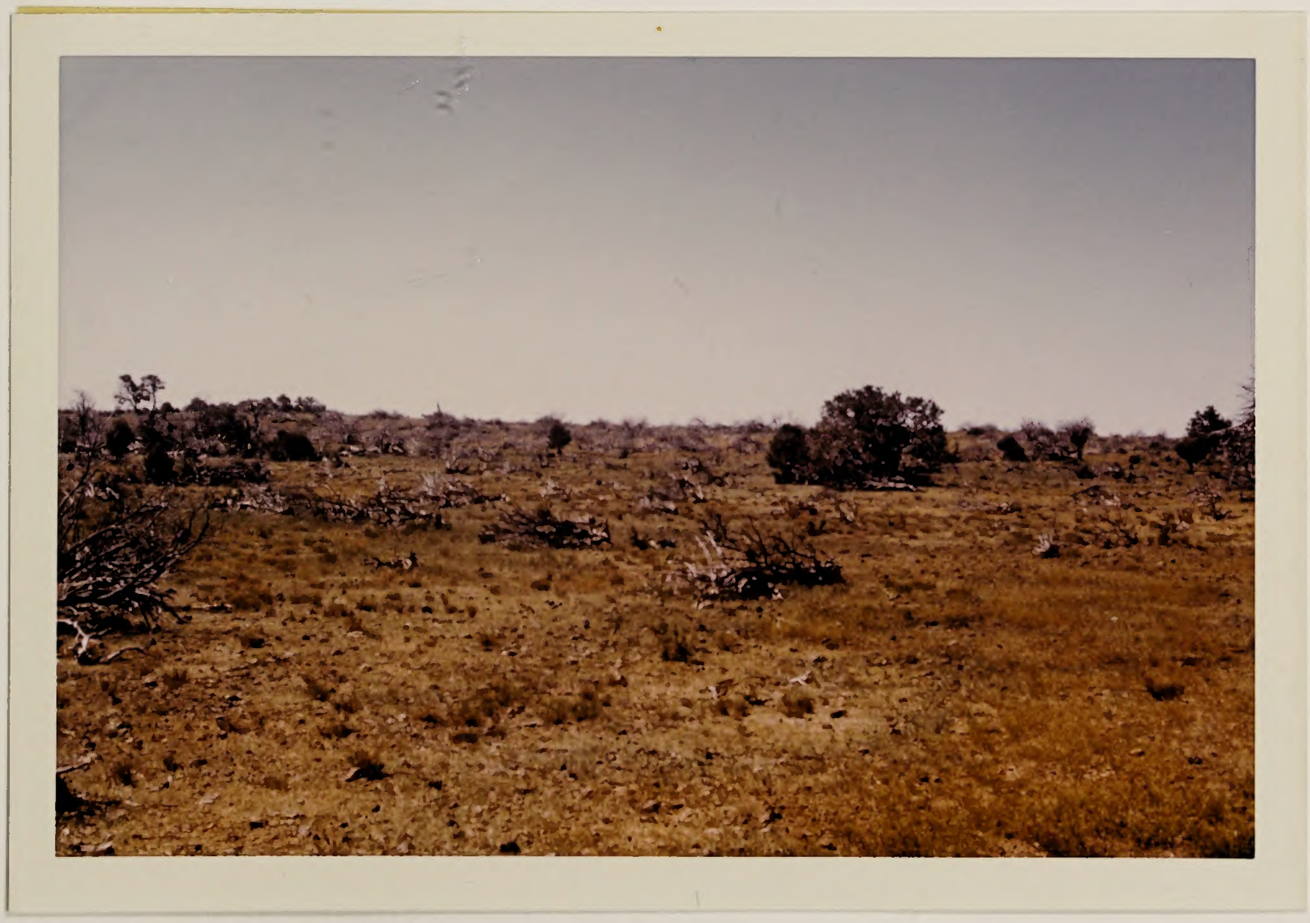
Picture showing juniper density at 4000 ft. near Camp Verde, Arizona



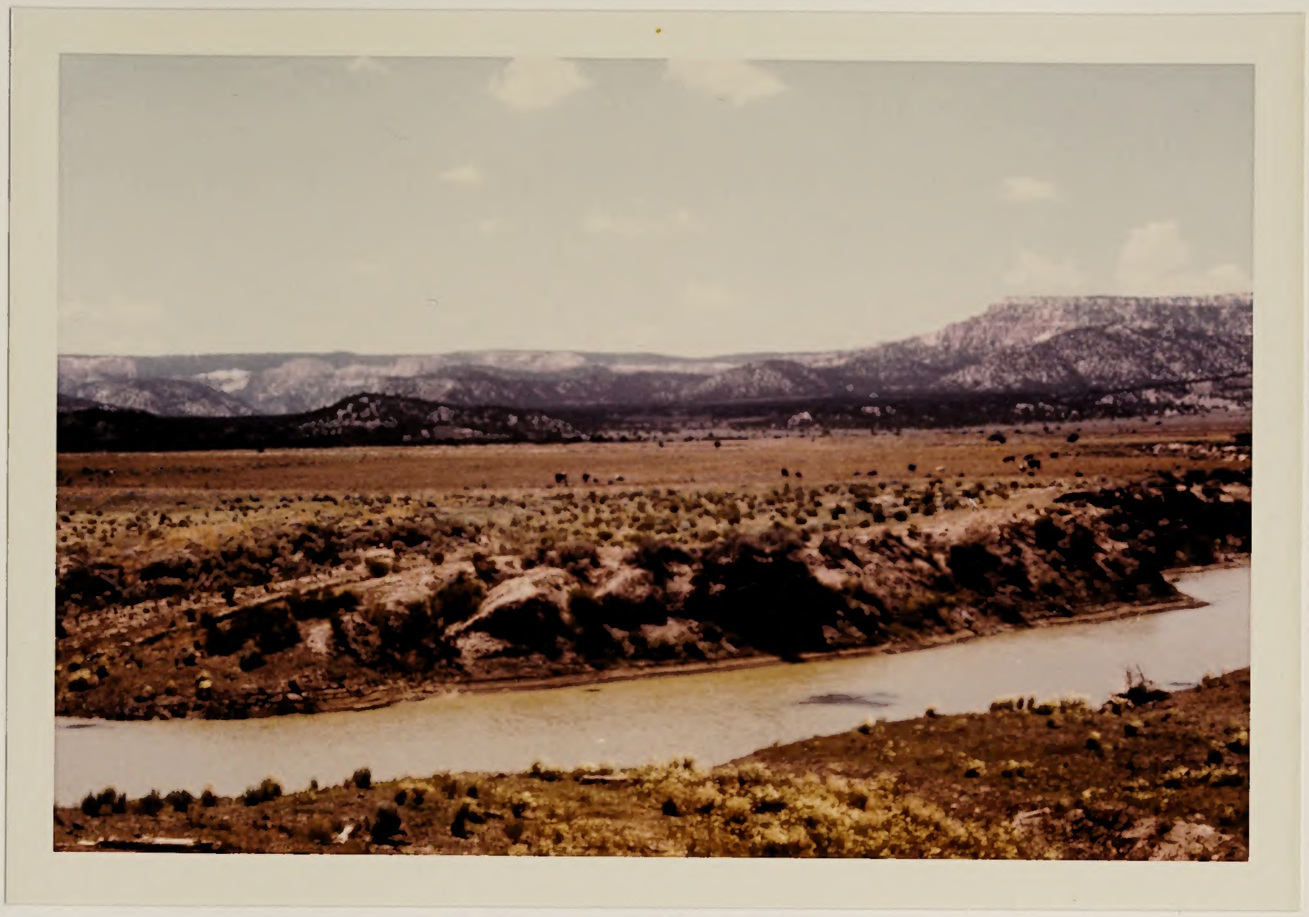
Picture showing increased juniper density further north of Camp Verde, Arizona



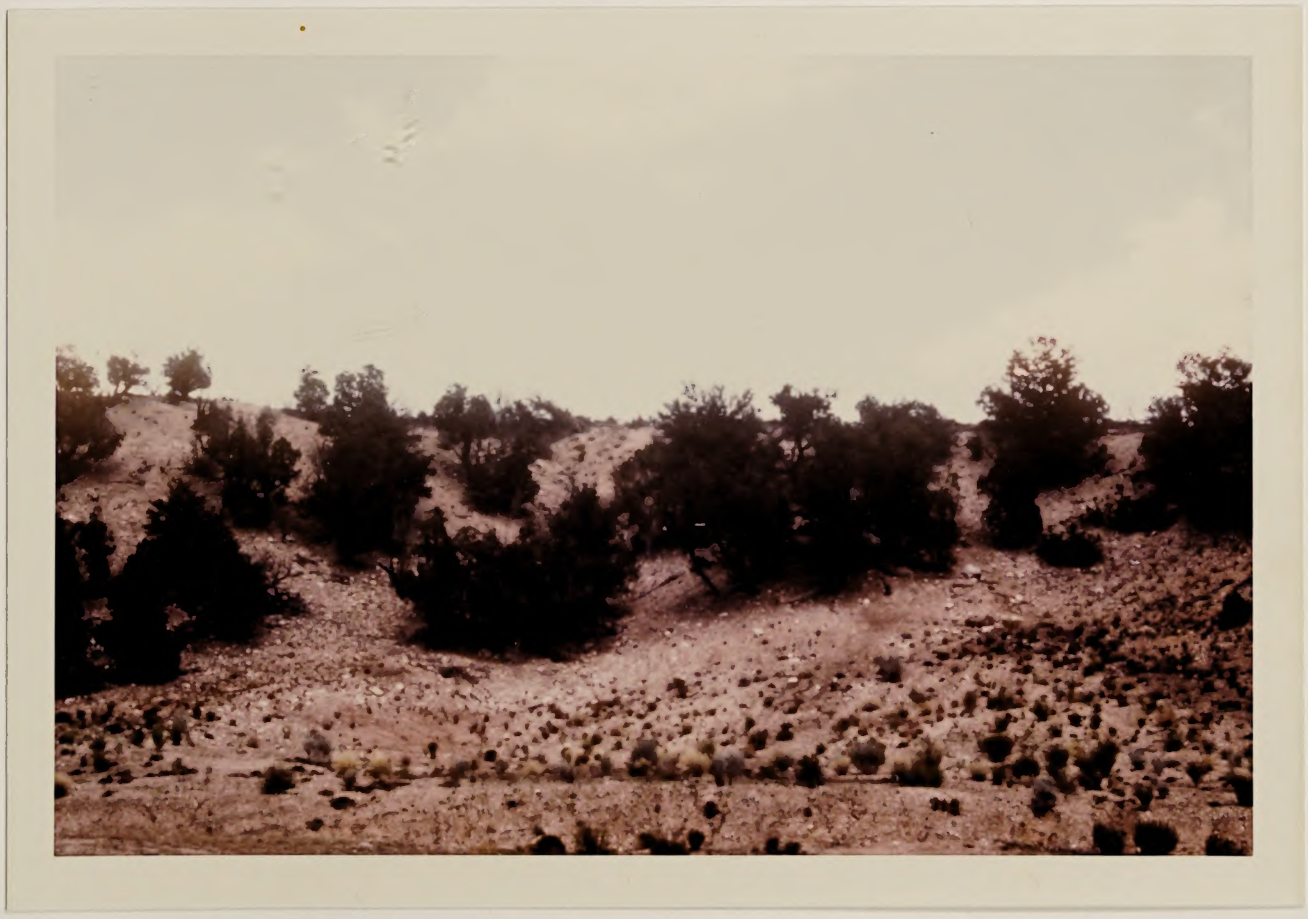
Juniper density at highest point northest of Camp Verde, Arizona elevation near 5000 feet



Alligator juniper dozed over-plot located on the Beaver Creek Watershed near Happy Jack, Arizona. Vegetative cover not effective Treatment went in-1965 on watershed number 6.reseeded 1972 with snakeweed and lovegrass

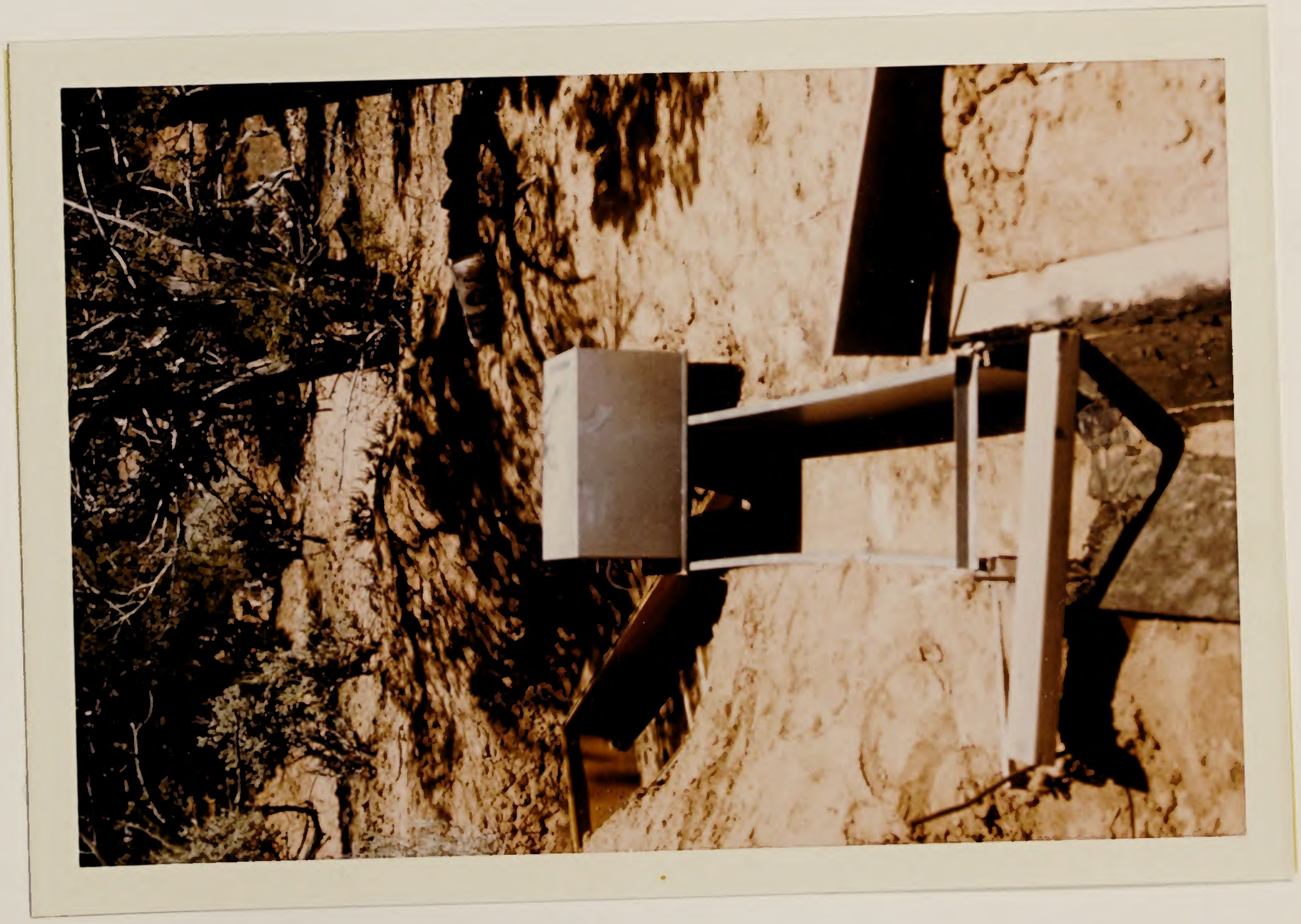


Sheepcreek watershed near Cannonville, Utah
area of sagebrush removal followed by building of retention dams
thus producing good pasture areas.

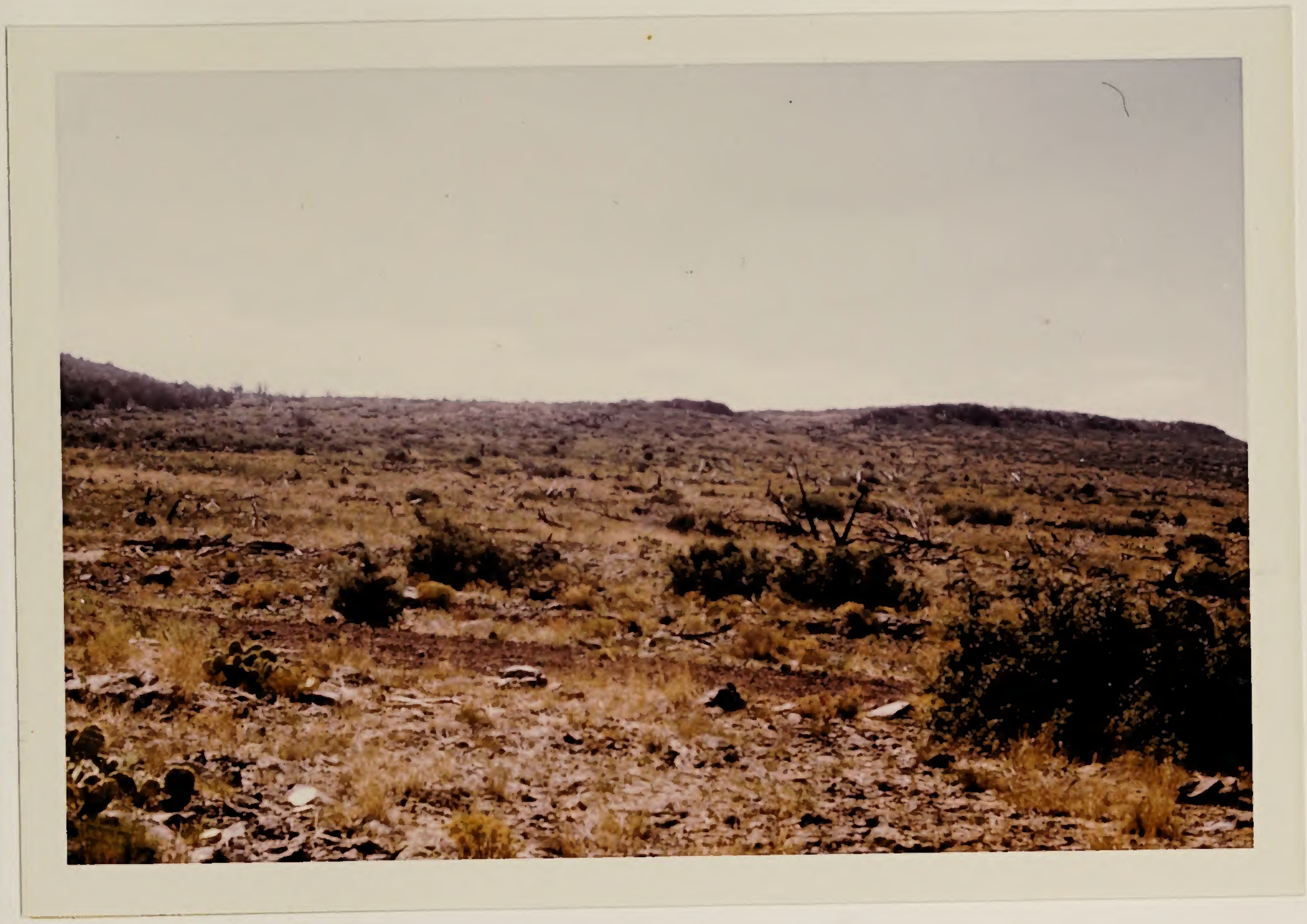


Sheepcreek watershed adjacent area depicting view before
treatment program initiation in 1966

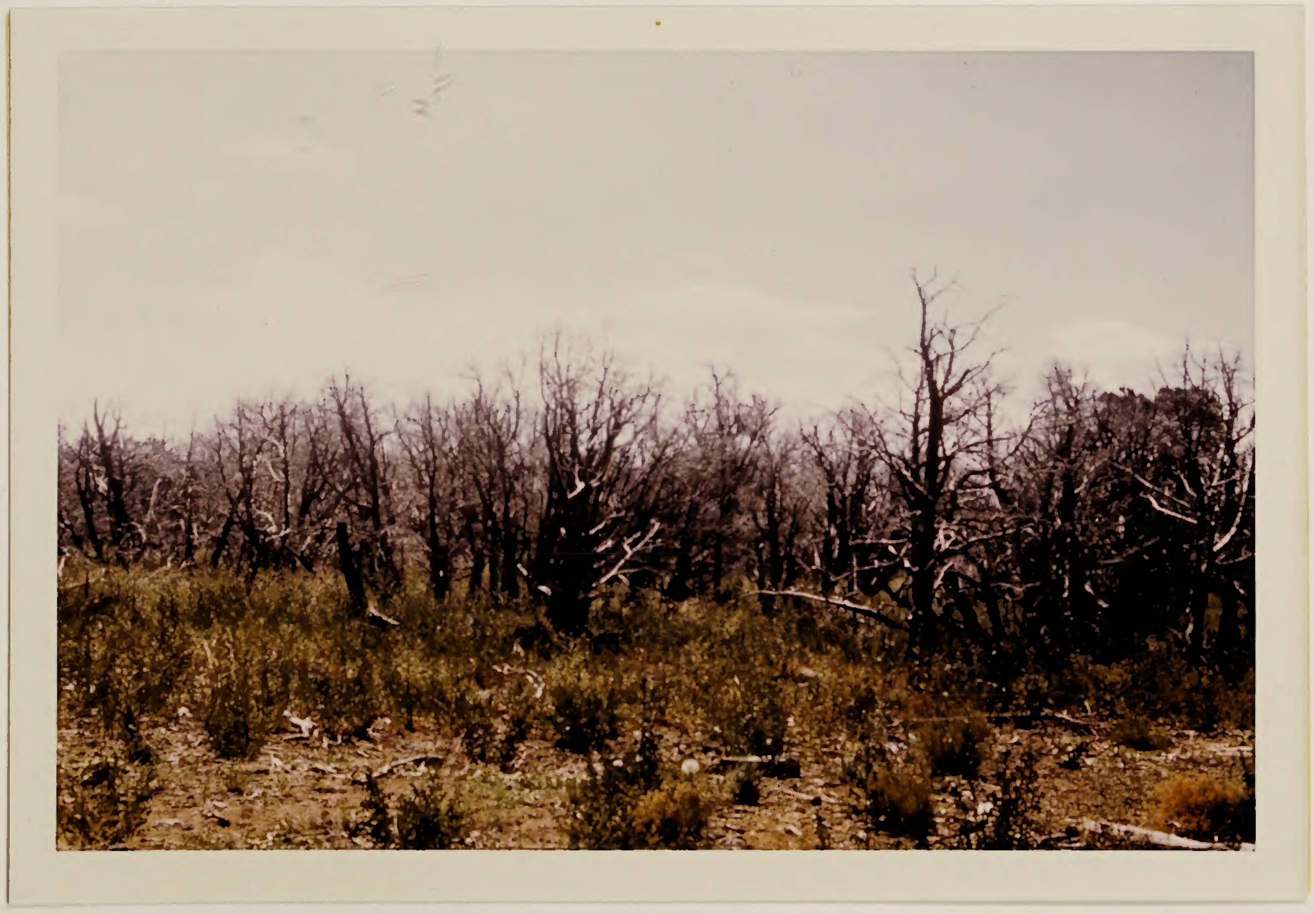
Photograph shows cryptogam cover intensity on surface soils of .1 acre runoff control plots-Maverick Point Resource Conservation area



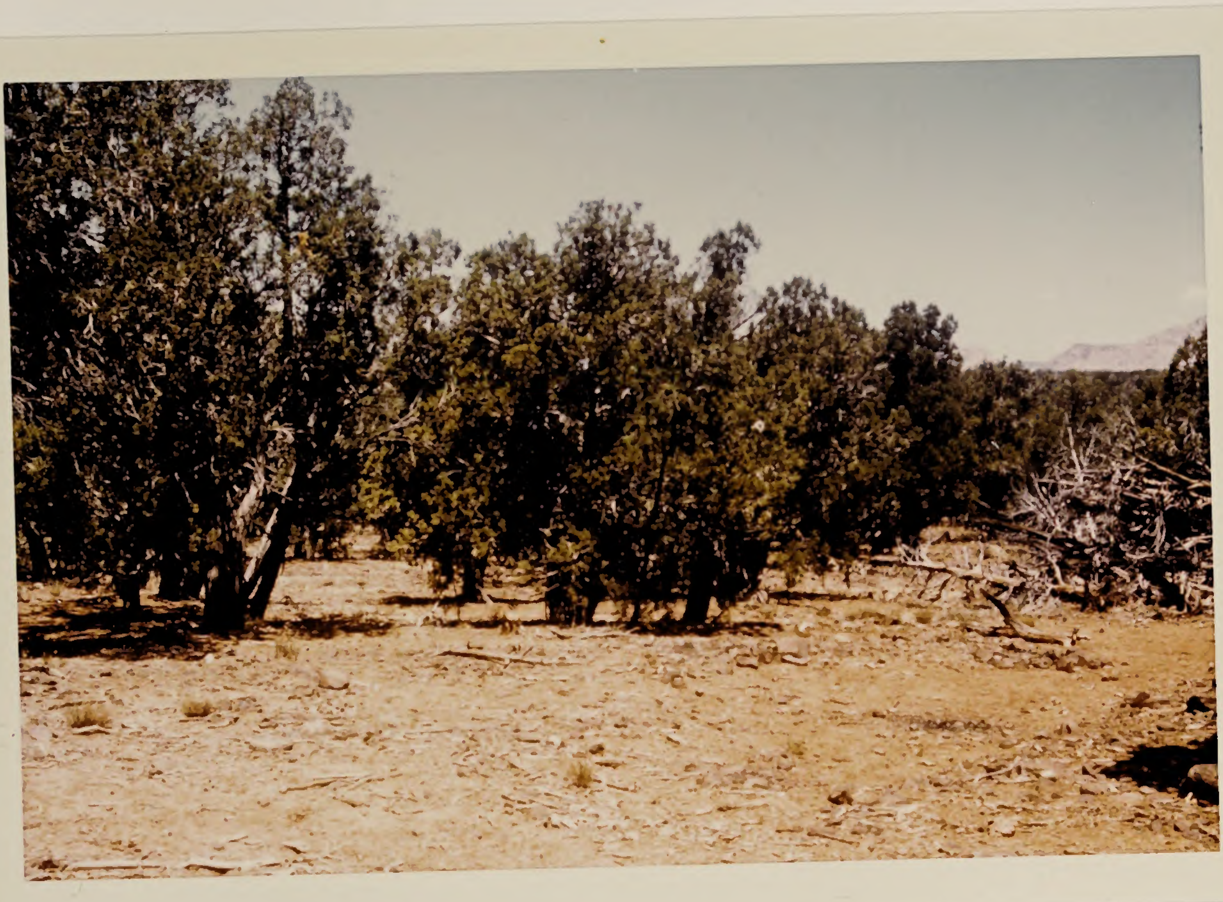
.1 Acre runoff control site-Maverick point resource conservation area. Before chaining was done on this spot of acreage- a .1 acre plot was measured off as a control site-3 to 4 control plots are spaced throughout the area for statistical comparison of chaining effects



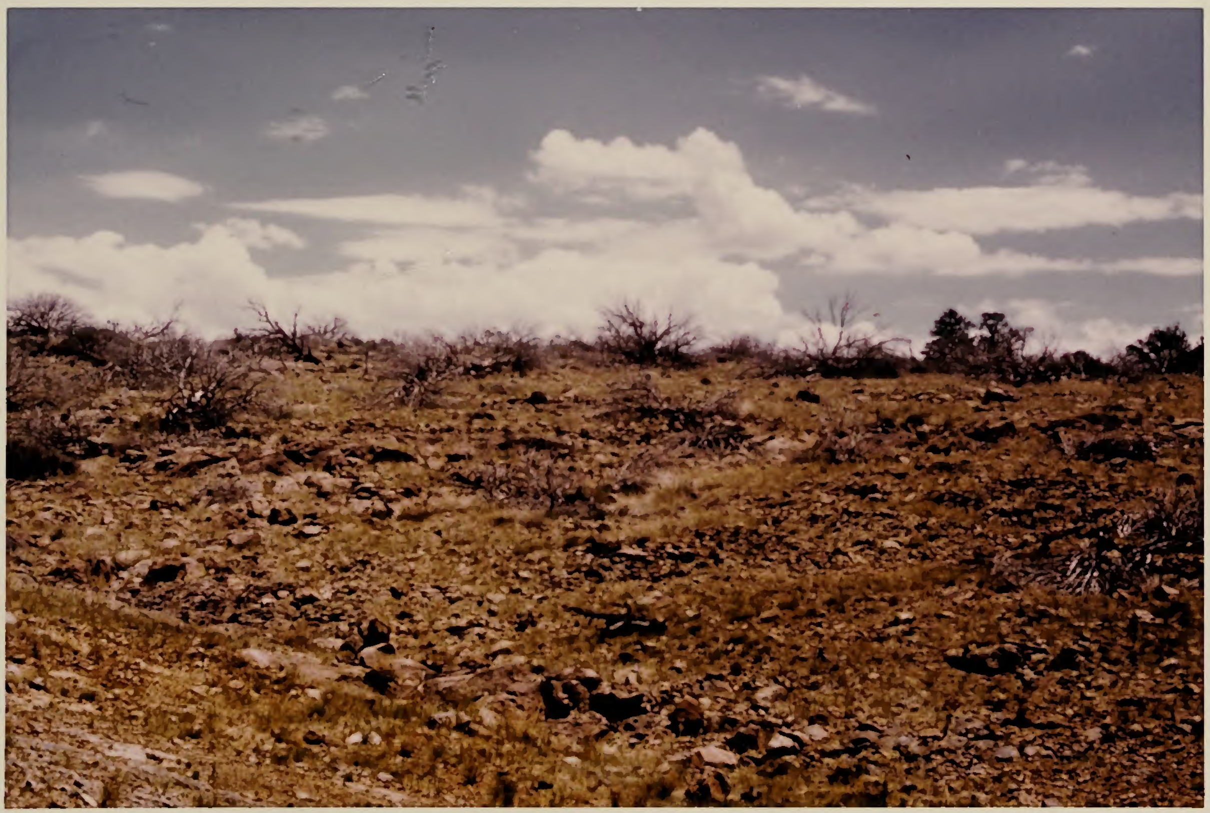
Utah juniper cabled with the slash burned-Beaver Creek Watershed
Treatment went in-1963 - Watershed number 1
seeded with lovegrass and side oat grama



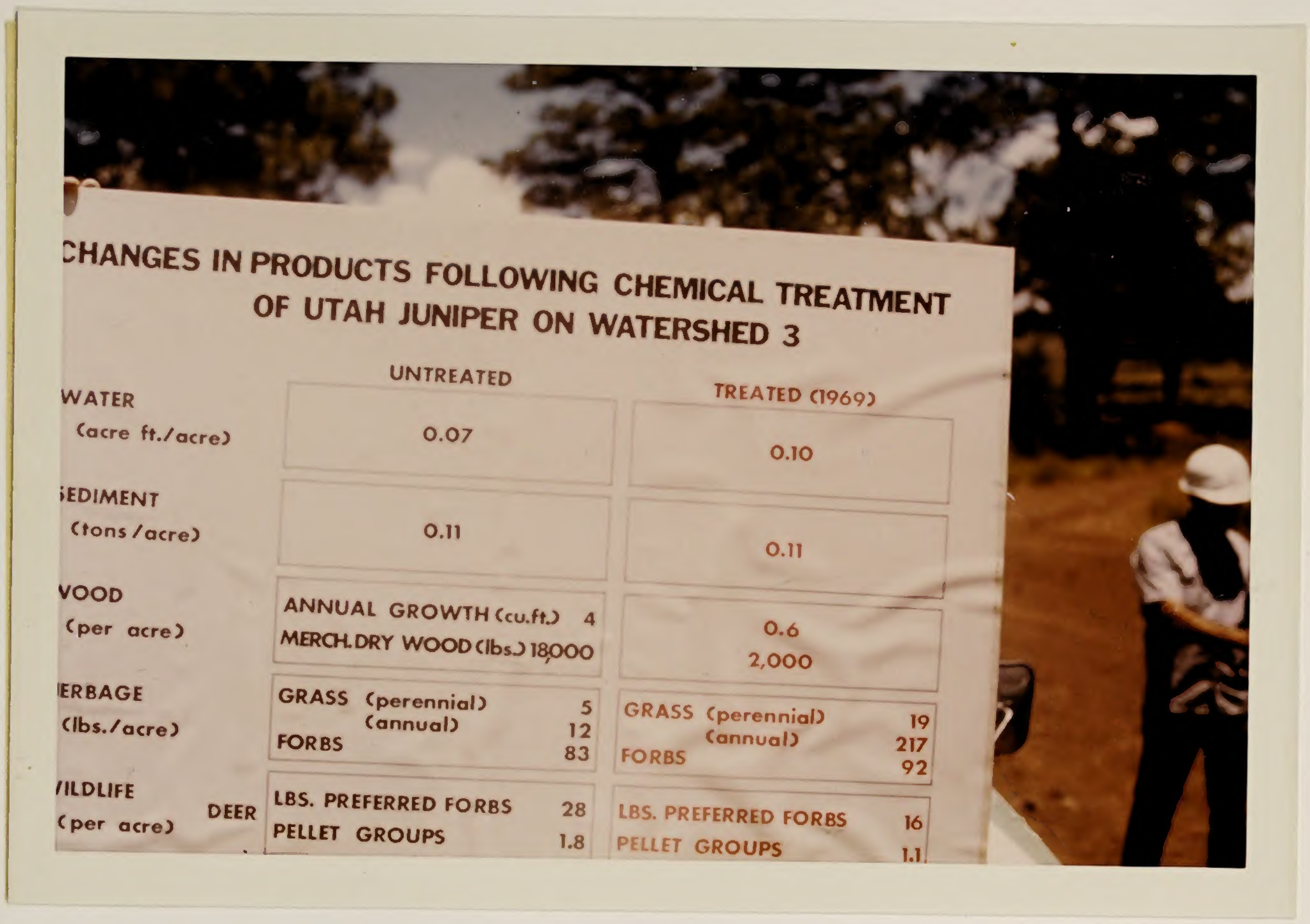
Utah Juniper chemically treated with 2½ lb of Picloran mixed with 5 lb of 2-4-dichlorobenzene per acre-aerial sprayed via helicopter in 1968 on Watershed number 3-Beaver Creek Watershed



Control area (Untreated)-Beaver Creek Watershed



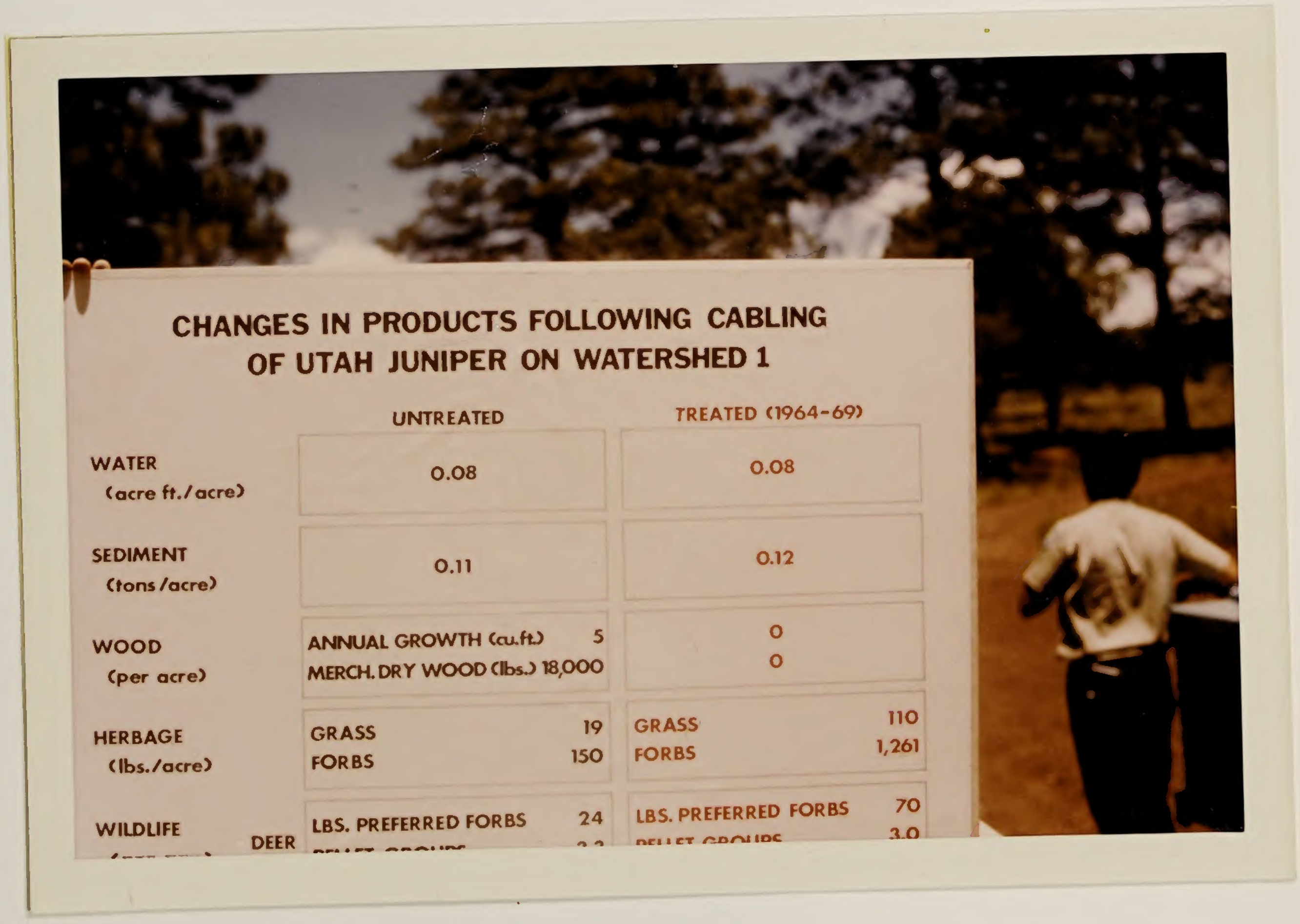
Utah Juniper-saw treatment-portion of watershed number 6



CHANGES IN PRODUCTS FOLLOWING CHEMICAL TREATMENT
OF UTAH JUNIPER ON WATERSHED 3

		UNTREATED	TREATED (1969)
WATER (acre ft./acre)		0.07	0.10
EDIMENT (tons/acre)		0.11	0.11
OOD (per acre)		ANNUAL GROWTH (cu.ft.) 4 MERCH. DRY WOOD (lbs.) 18,000	0.6 2,000
ERBAGE (lbs./acre)		GRASS (perennial) 5 (annual) 12 FORBS 83	GRASS (perennial) 19 (annual) 217 FORBS 92
ILDLIFE (per acre)	DEER	LBS. PREFERRED FORBS 28 PELLET GROUPS 1.8	LBS. PREFERRED FORBS 16 PELLET GROUPS 1.1

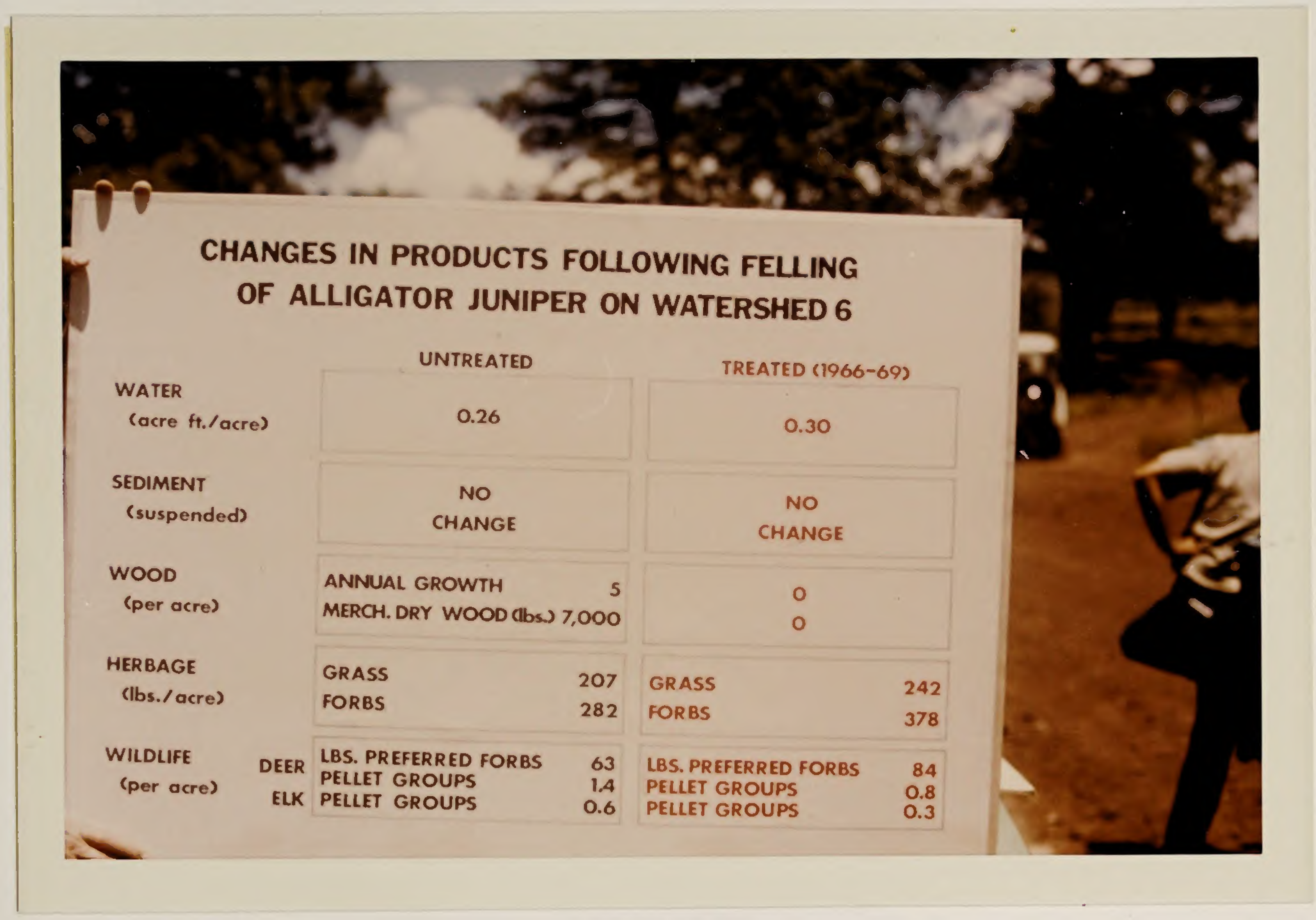
Chart-data showing changing in products following chemical treatment of Utah Juniper on Watershed number 3



CHANGES IN PRODUCTS FOLLOWING CABLING
OF UTAH JUNIPER ON WATERSHED 1

		UNTREATED	TREATED (1964-69)
WATER (acre ft./acre)		0.08	0.08
SEDIMENT (tons/acre)		0.11	0.12
WOOD (per acre)		ANNUAL GROWTH (cu.ft.) 5 MERCH. DRY WOOD (lbs.) 18,000	0 0
HERBAGE (lbs./acre)		GRASS 19 FORBS 150	GRASS 110 FORBS 1,261
WILDLIFE	DEER	LBS. PREFERRED FORBS 24	LBS. PREFERRED FORBS 70 3.0

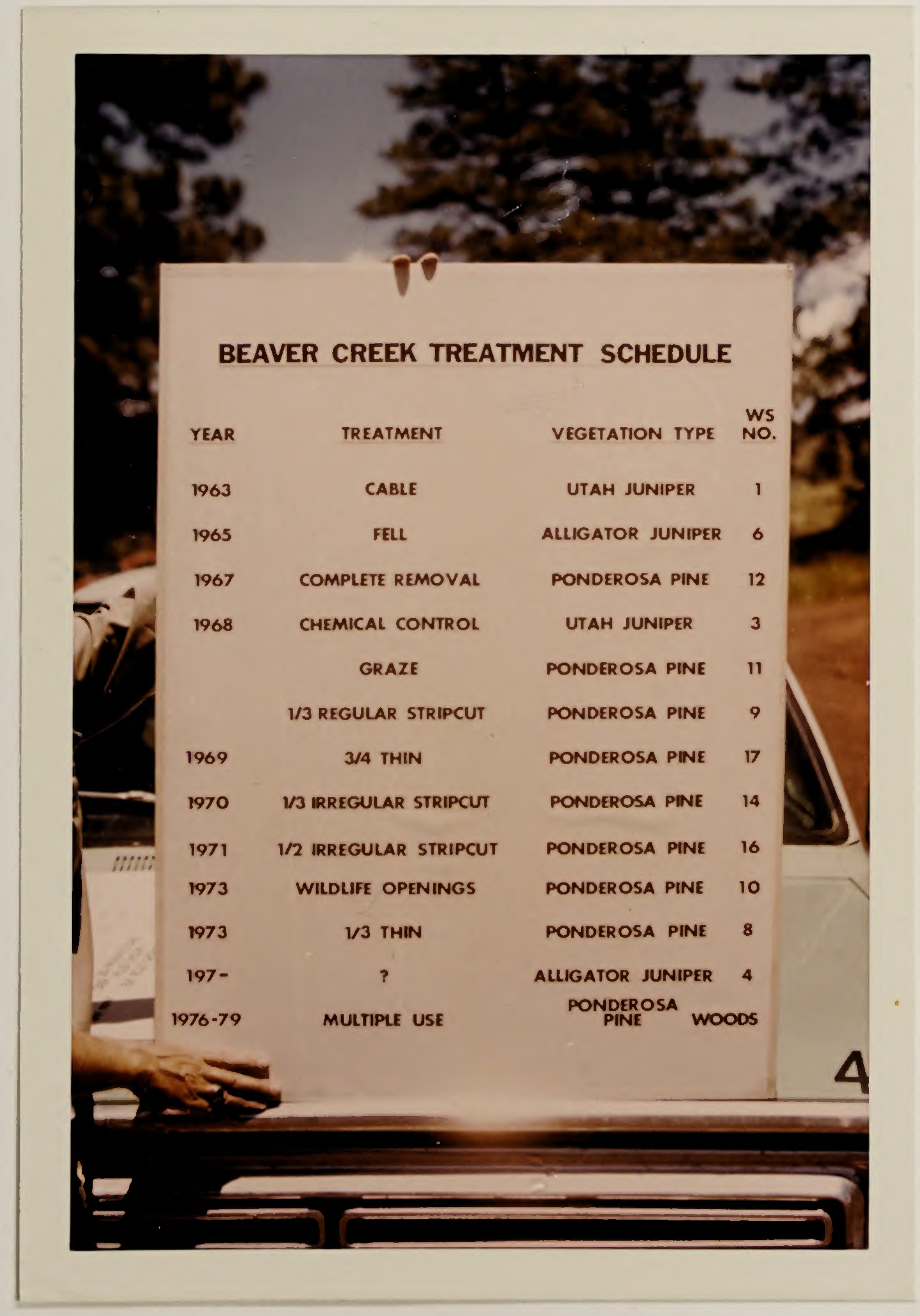
Chart-data showing changes in products following cabling of Utah Juniper on watershed number 1



CHANGES IN PRODUCTS FOLLOWING FELLING OF ALLIGATOR JUNIPER ON WATERSHED 6

		UNTREATED	TREATED (1966-69)
WATER (acre ft./acre)		0.26	0.30
SEDIMENT (suspended)		NO CHANGE	NO CHANGE
WOOD (per acre)	ANNUAL GROWTH	5	0
	MERCH. DRY WOOD (lbs.)	7,000	0
HERBAGE (lbs./acre)	GRASS	207	242
	FORBS	282	378
WILDLIFE (per acre)	DEER LBS. PREFERRED FORBS	63	84
	PELLET GROUPS	1.4	0.8
	ELK PELLET GROUPS	0.6	0.3

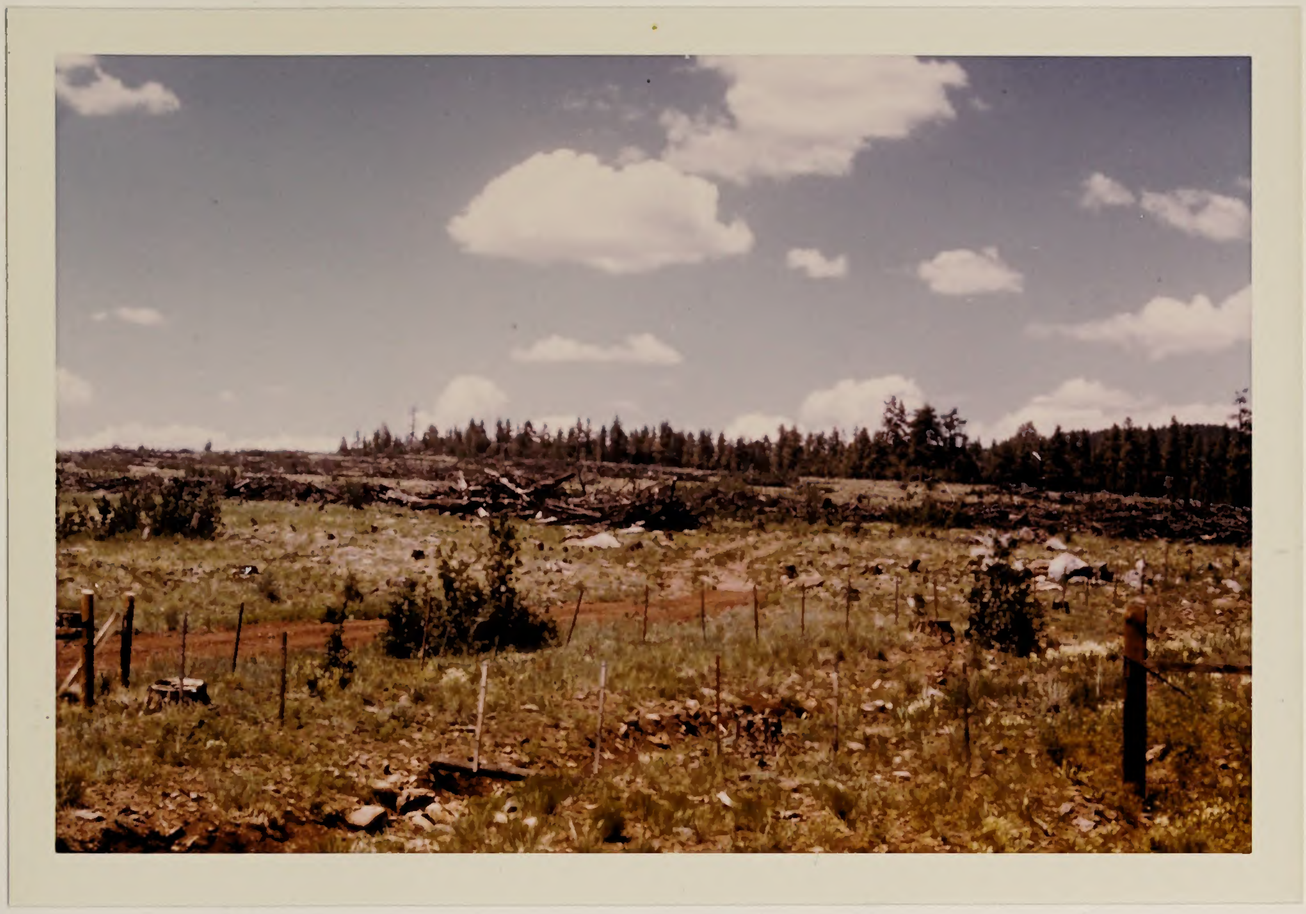
Chart-data showing changes in products following felling of Alligator Juniper on Watershed number 6



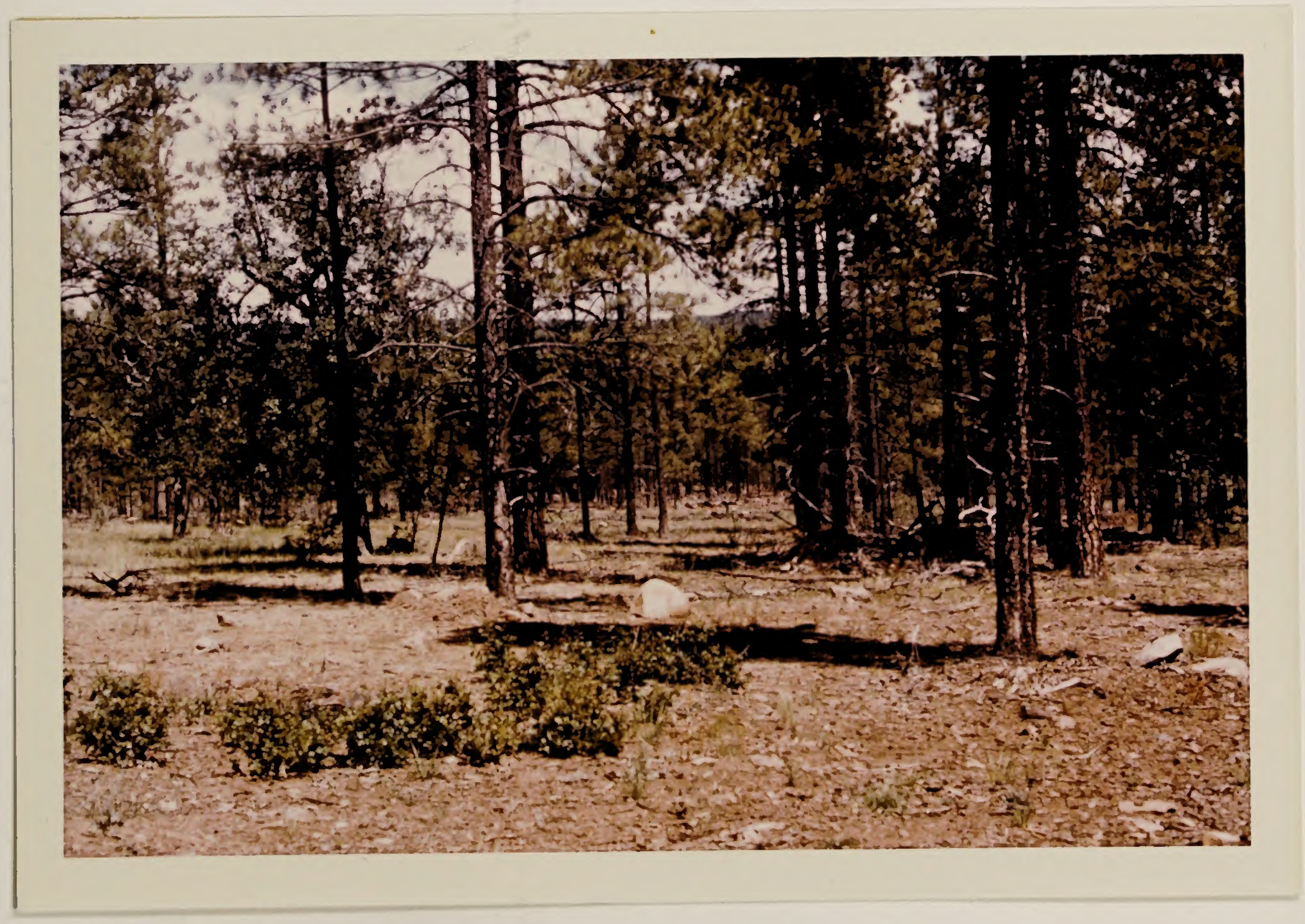
BEAVER CREEK TREATMENT SCHEDULE

YEAR	TREATMENT	VEGETATION TYPE	WS NO.
1963	CABLE	UTAH JUNIPER	1
1965	FELL	ALLIGATOR JUNIPER	6
1967	COMPLETE REMOVAL	PONDEROSA PINE	12
1968	CHEMICAL CONTROL	UTAH JUNIPER	3
	GRAZE	PONDEROSA PINE	11
	1/3 REGULAR STRIPCUT	PONDEROSA PINE	9
1969	3/4 THIN	PONDEROSA PINE	17
1970	1/3 IRREGULAR STRIPCUT	PONDEROSA PINE	14
1971	1/2 IRREGULAR STRIPCUT	PONDEROSA PINE	16
1973	WILDLIFE OPENINGS	PONDEROSA PINE	10
1973	1/3 THIN	PONDEROSA PINE	8
197-	?	ALLIGATOR JUNIPER	4
1976-79	MULTIPLE USE	PONDEROSA PINE	WOODS

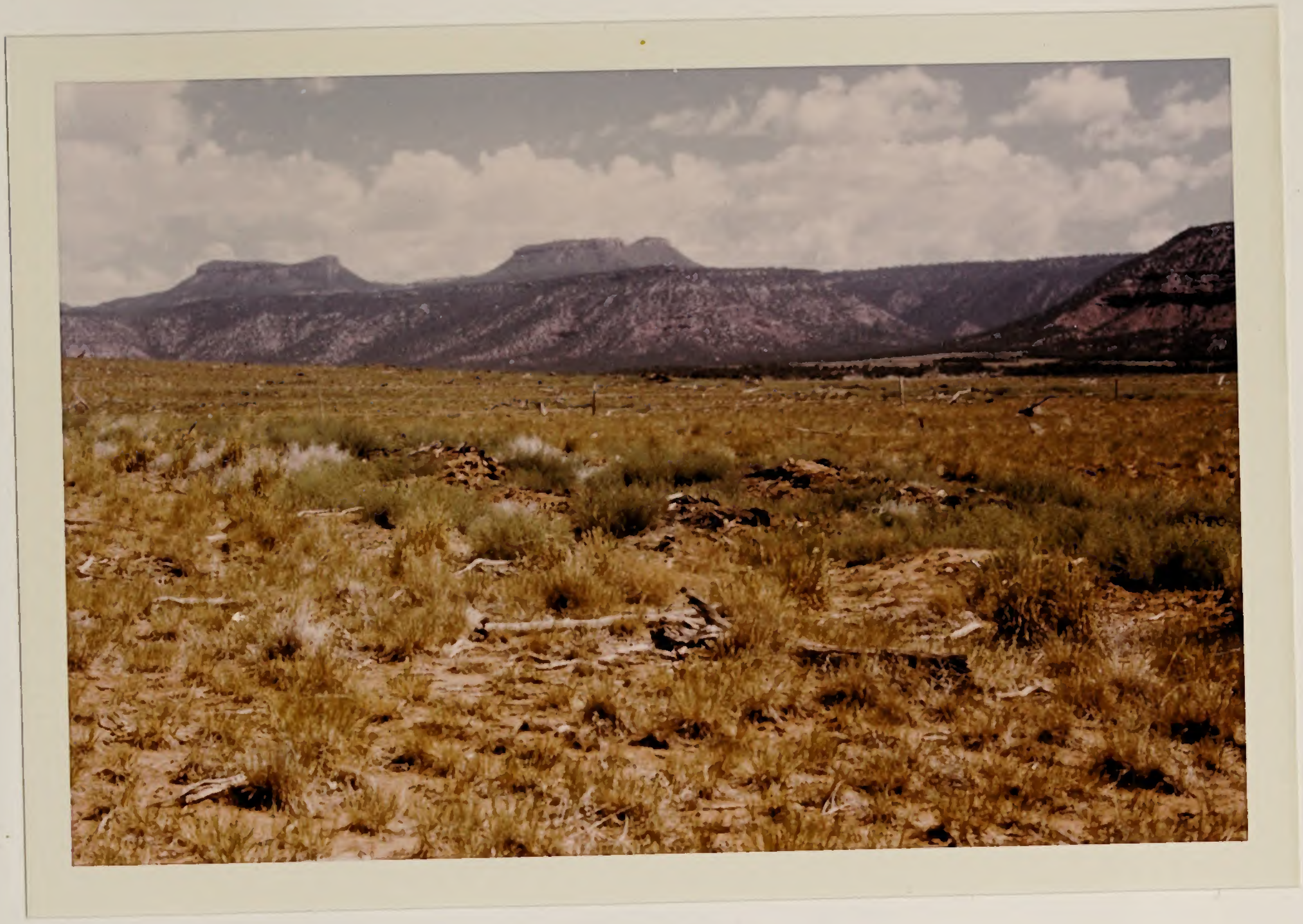
Chart showing treatment schedules 1963-1979



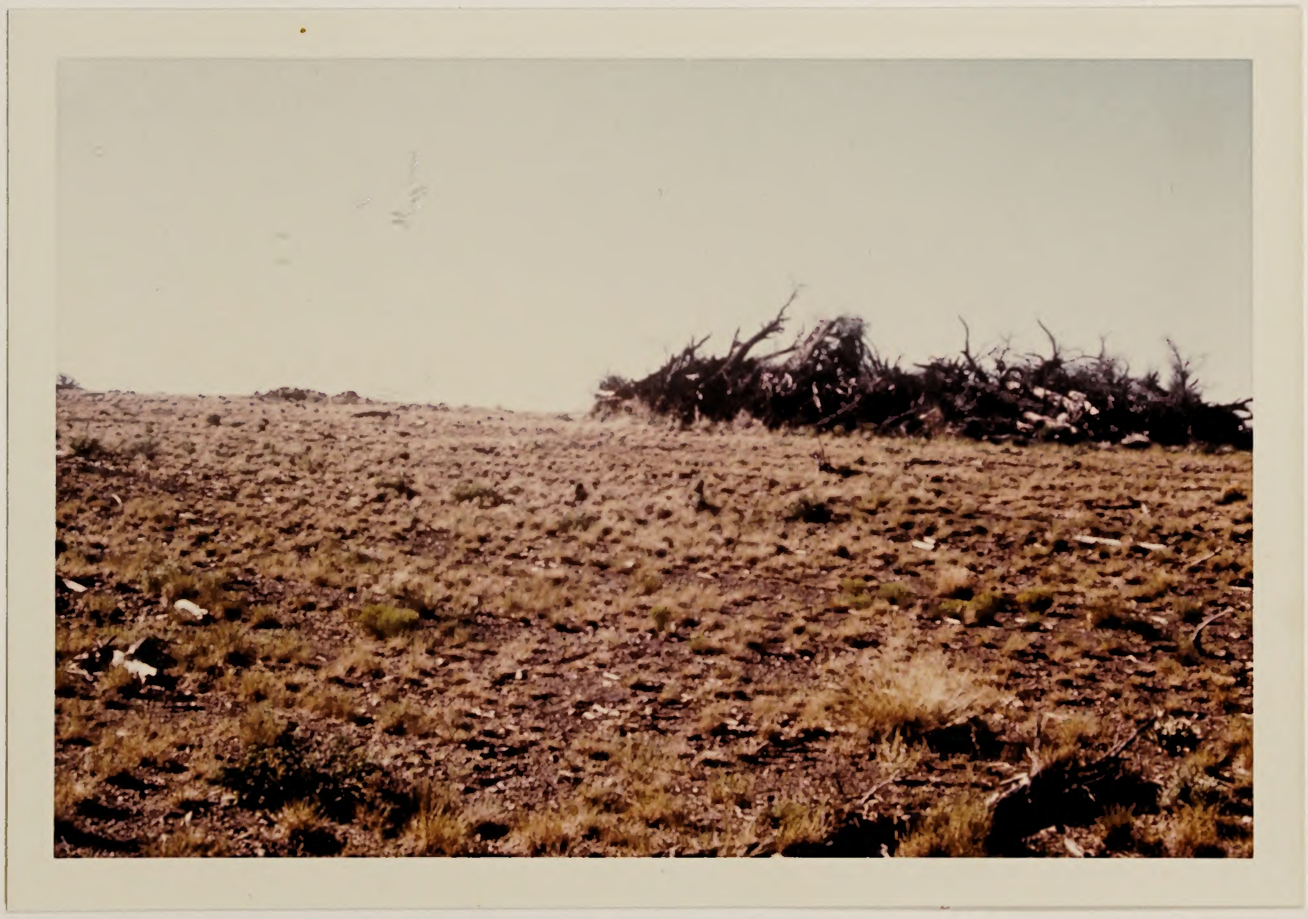
Ponderosa Pine clearcut area followed by windrowing 1968 on watershed number 9



Ponderosa pine 3/4 thinned in 1969 on watershed number 17



Maverick point resource conservation area-Wheatgrass monoculture protected area (Gifford's studies)



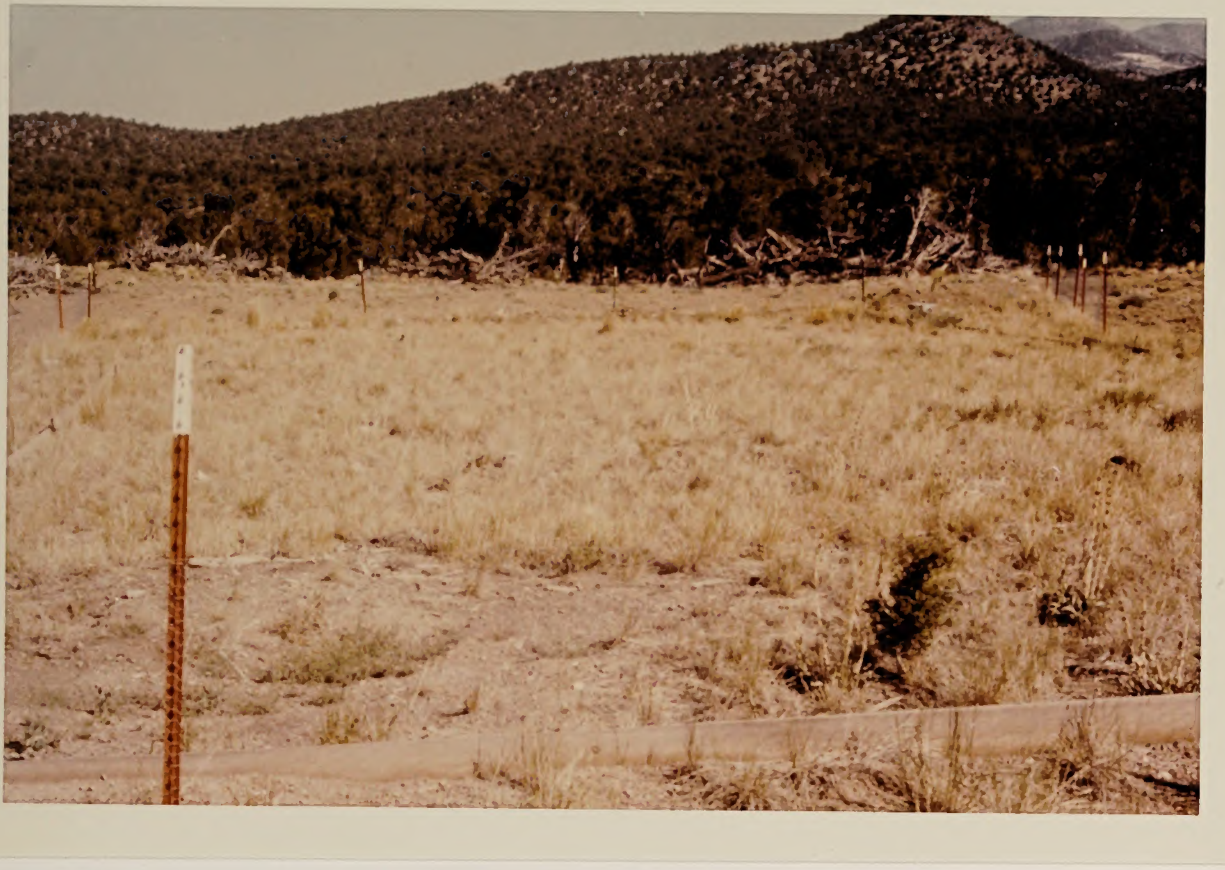
Windrowed, drill seeded with

crestedwheatgrass (Milford, Utah)

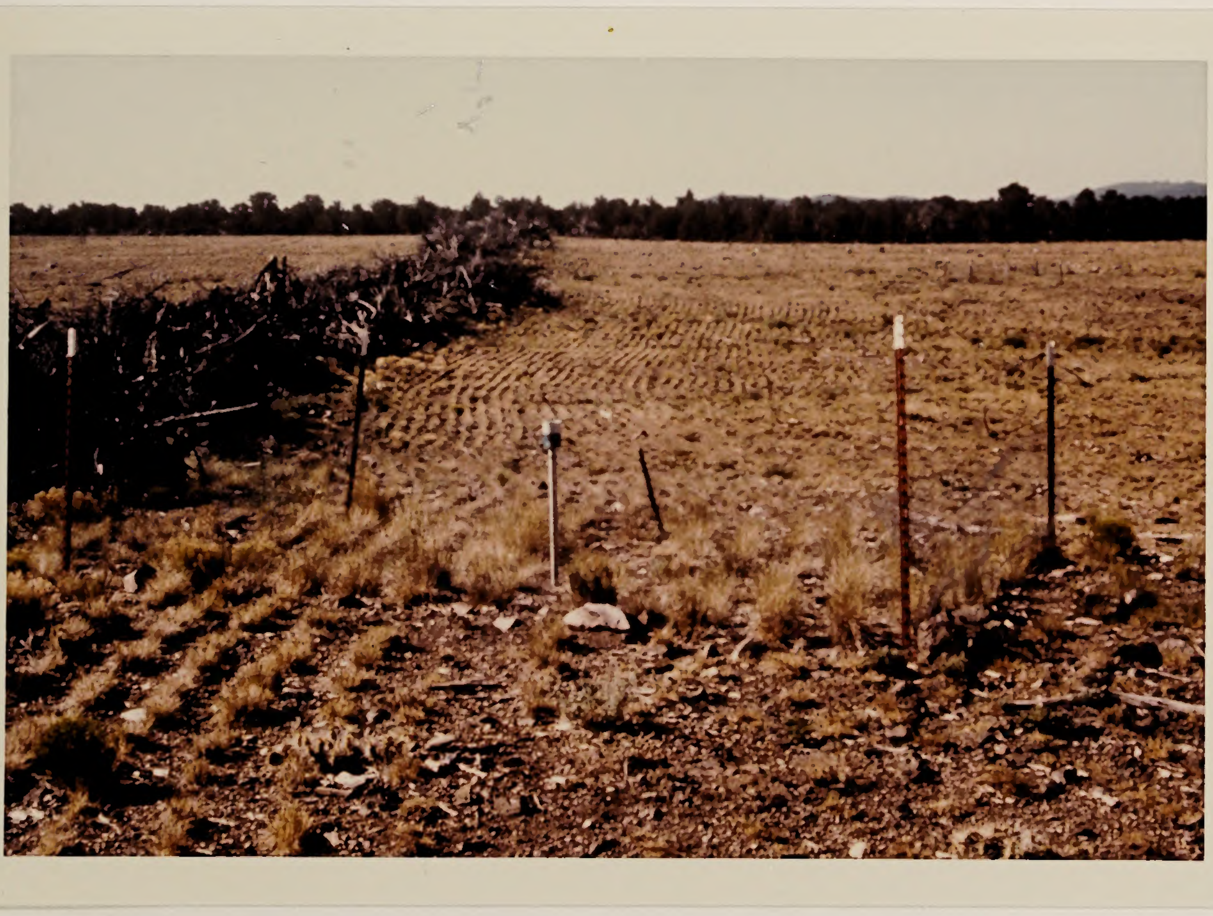
Another view of a .1 acre runoff control plot

Debris in place site depicting fast reestablishment of pinyon-juniper type species - area is a .lacre runoff plot (Debris in place)

.1 acre runoff control plot-Milford, Utah

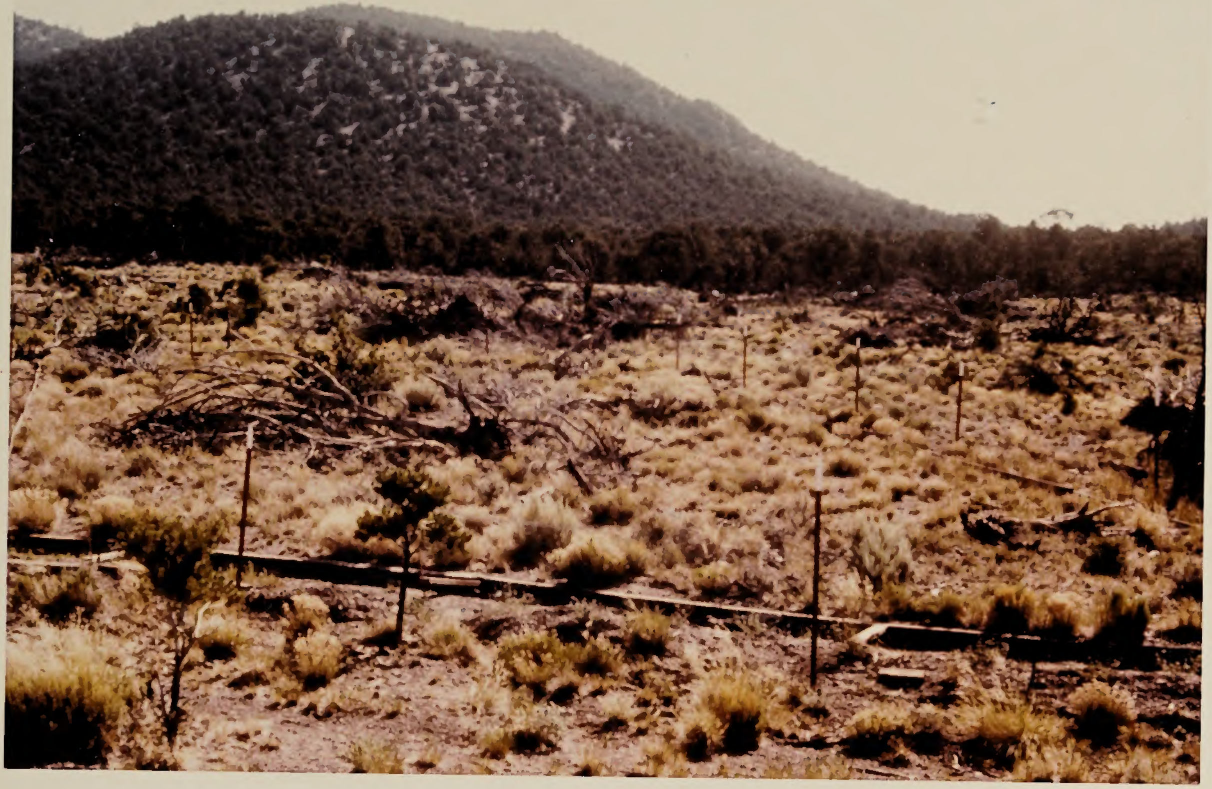


.1 Acre runoff -windrow control plot-Milford, Utah



.1 acre runoff windrowed area chained and fenced off to protect resulting cover from wildlife

soil moisture measurement device inside fence



Debris in place shot (area) * Milford,Utah

PART V

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